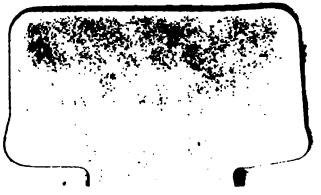
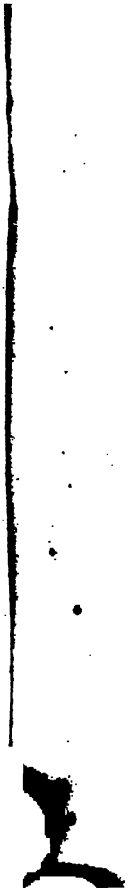
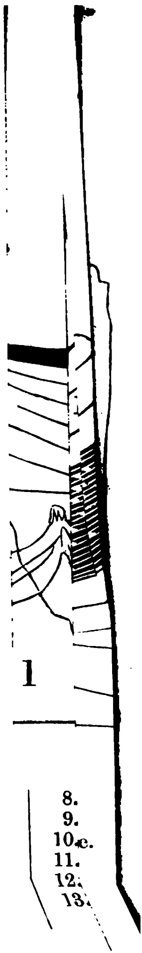





1
8.
9.
10.c.
11.
12.
13.

FIRST LESSONS

IN

GEOLOGY;

WITH A SPECIAL ARTICLE ON THE TOADSTONES OF DERBYSHIRE,

AND A

GLOSSARY, EXPLANATORY OF GEOLOGICAL TERMS, AND THEIR DERIVATIONS.

WITH SECTIONS, AND A
GENERAL DIAGRAM OF THE STRATA.

BY W. ADAM,

AUTHOR OF "THE GEM OF THE PEAK," AND OF
"THE GEOLOGY, MINERALOGY, AND BOTANY OF DERBYSHIRE."

"Find tongues in trees, books in the running brooks,
Sermons in stones, and good in everything."

DERBY:
PUBLISHED BY J. AND. C. MOZLEY,
AND 6, PATERNOSTER ROW, LONDON;
W. & W. PIKE; WILKINS & SON; SMITH & SON, RAILWAY STATION;
BEMROSE & SONS, MATLOCK BATH; GOODWIN & GRATTON, BAKEWELL;
TURNER, HALL BANK; W. B. SUTTON, LIBRARY AND HERALD OFFICE,
J. & J. C. BATES, LIBRARY AND ADVERTISER OFFICE, BUXTON,
AND ALL OTHER BOOKSELLERS.
1857.


BIBLIOTHECA · BODLEIANA ·

PREFACE.

BEING frequently asked by parties, when Lecturing at some of the Institutions and Schools during my tours throughout the country, whether there was any book on Geology suited for Schools and the people generally, my answer was invariably in the negative; not being able to point out any work that was really adapted for young people and parties ignorant of the science. Most of the books published were either too bulky, too expensive, or not written with a view to any class except those who had obtained a liberal, or rather extended education. Besides, the array of "hard names," as they are termed, found in all Geological works, deterred many from encountering the science, and almost entirely prevented Geology from being introduced into Schools. Hence originated a strong desire on my part to see a *small, cheap* work written and published, giving a clear, but comprehensive *outline* of the science, with a Glossary of Geological terms, so as to adapt this deeply-interesting and noble science to most readers, especially to the young. But it was not before a conversation I had with Sir Roderick Murchison, when he did me the honour to preside at a Lecture I gave in the Ball-Room, Buxton, some time ago, when he named the desirableness of having a Glossary, that I *seriously thought* of undertaking such a work

myself; for I felt it was no easy task to give a short, clear, and comprehensive view of a science so extensive and difficult as Geology, and only, as yet, progressing onwards to perfection. Whether I have succeeded in this little unpretending volume, in producing a work adapted for teaching the young, I must leave the public to judge, simply observing that I have tried my best to do so; and where my own *practical* knowledge failed on any point of the wide field which Geology occupies, I have always consulted the works of those eminent men who have so ably written on the subject; as, Doctor Buckland, Sir Roderick Murchison, Sir Charles Lyell, Professors Anstead and Phillips, Conybeare and Phillips, the late Mr. Hugh Miller, &c. together with the assistance of a gentleman perfectly acquainted with the fossil department of the British Museum, who very kindly revised the sheets as they issued from the press.

The slight sketch given of the "Economic Geology of England and Wales," at the end, will, I hope, show the reading public how much we are indebted to the *Geological character* of this country, for much of that fertility of soil, and that productiveness of iron, coal, and other minerals with which Great Britain abounds, and to which is due, under the blessing of Divine Providence, the prosperity and high position to which we have attained amongst the nations of the earth.

Matlock, August 12, 1857.

INTRODUCTION.

GEOLOGY is now of such acknowledged importance that little need be said to recommend it to the attention of every one who has the *care* of training the youthful mind to a knowledge of really useful and practical things—things adapted to the character and future pursuits of the youth of both sexes, and which may enable them to fulfil their mission through life with the greatest possible advantage to themselves and benefit to their fellow-men. Now geology is one of those sciences which ought not to be neglected in the education of youth in an age which is eminently practical.

In mining, building, and engineering operations geology is essentially necessary, as it not only points out to us the nature of the materials on which we are about to act, but also points out to us the very spots where we may find coal, *iron, silver, gold*, precious stones, &c. or, in fact,

any of those useful materials required for the comfort or advancement of mankind. It was a practical knowledge of this science that enabled Sir Roderick Murchison, in 1846, at a meeting of the Geological Society of Cornwall, to state that gold could be found in Australia; and to prove this, Sir Roderick sent out two Cornish miners, who returned in about two years with gold in their hands; and we now know the immense importance to us of such a discovery in that colony.

But geology is comparatively a *new* science; and why is this? Simply because it required the knowledge and development of other sciences before it could be studied or carried out efficiently. Chemistry and mineralogy were very imperfectly known and understood even at the commencement of this century. Botany, natural history, comparative anatomy, and other sciences relating to heat, electricity, &c. had not obtained their full development, and without a due knowledge of some, or all of these, the practical study of geology would have been impossible, or at least unproductive of any benefit to man. Geology also, not being confined to any given region of the earth, but embracing the whole in its mighty grasp, required that the earth should be explored *to its utmost limits* in order to furnish sufficient *data for the beautiful superstructure of geology.*

which embraces not only the *present* but the past ages of all time.

In compiling this small work for the use of schools we shall be as simple as possible, and commence with the lowest rock, (granite,) and follow the ascending series till we reach the surface, or upper rocks.

On passing over a country, especially if it be a hilly or mountainous district, we cannot help being struck with the *apparent disorder* existing on the face of the whole space presented to our view. Hills of different magnitude appear, some grouped together, others in continuous ridges, with valleys of various breadth between. Here an abrupt precipice, there a low cliff, or some other modification of an Alpine district, and beyond, it may be, the low, but beautifully swelling eminences of a champagne country, fertilized by a fine flowing river. In all this, however, the most perfect order and harmony prevail, which it is the province of geology to point out.

Two important circumstances are the result of this beneficent arrangement of the earth's surface. The one is the origin of springs and streams of water; the other, owing to the culminating edges of the strata, the mineral wealth of a world is brought to, or near the surface, and becomes *available for the* numerous wants of mankind;

while this very variety of aspect produces in our minds the most delightful sensations in taking our walks, rides, or drives, through the country. "What a magnificent landscape is that!" says one. "If it could but be faithfully conveyed to the canvass how I should like to have it." "But what an exquisite drawing this would make," another might say, (when confined within some narrow dale or dell) "for my portfolio or album; I think I will sketch it;" neither party, not even for a moment, reflects on the *cause* of that beautiful variety in nature, which excites and commands their admiration. "How manifold are Thy works, O Lord! in wisdom hast Thou made them all: the earth is full of Thy goodness."* We shall try to keep these truths in view while writing this little book for the young student in geology.

* Psalm civ. 24

IMPORTANCE OF GEOLOGY.

To a common observer there would appear to be nothing in this science, either attractive or instructive. Why is this? The answer can only be, want of knowledge. For no science presents itself to the human mind under such a variety of aspects, or communicates such valuable information to man. Like botany, it is everywhere to be seen, everywhere to be studied, whether we take a simple morning stroll either in town or country. Is it of no importance to inform ourselves on what we tread? The gravel or pebbles which form our walks were in past time filled with life, and enjoyed happiness as we do now. One pebble may have been a *living sponge*, or fragment of one; another may have been, and *no doubt* was, a mass originally of living *infusoria*. This was proved to be the case by Doctor Mantell. Also the stones with which we make and mend our roads, have had *their living day* of myriads of creatures, and all our sedimentary rocks are full of what have been aptly called "THE MEDALS OF CREATION." Then look at its aspects on *building* stones. How *many blunders* would have been prevented, especially in public buildings, *if the architect* had known geology practically!

Also the proper rocks fit for manures, lime-burning, &c. But look at its agricultural aspects. It teaches us the *nature of soils*, and the materials of which these soils are composed. A matter of the deepest importance to the *horticulturist* as well as the agriculturist. Without this knowledge he may *dress* his ground improperly, or from old custom, and never improve. And although these are obvious truths, thousands of young people of both sexes are sent out into the world ignorant of a science, that would be of the utmost use to them throughout life. To the young lady, it would teach her how best to manage her "pet garden;" or, more useful still, as a *housewife* it would enable her to look after the general garden management with advantage; and to the country gentleman it is of immense importance, in teaching him the value of his estate, how to improve it, what are the natural properties of the soil or rocks on it, and, if a quarry exists, it will teach him what beds in that quarry are *durable* building-stones or *not*—for all beds are not *alike durable* even in the same quarry. And to the *engineer*, *civil* or *military*, it is, or *ought to be*, an essential part of education, to enable him to estimate, as nearly as possible, the difficulties he may meet with in carrying out his plans, from the nature of the ground and rocks on which he has to operate.

CHAPTER I.

CENTRAL HEAT, STATE OF THE EARTH'S SURFACE, AND CLASSIFICATION OF ROCKS.

THERE is now no doubt, but that the earth, at a great depth, is one mass of intensely heated matter,* and that the surface has been gradually cooled down to its present temperature. Several circumstances induce us to believe this. First, the weight of the earth being 5 times heavier than water, and the *crust*, or *surface*, being only $2\frac{1}{2}$ above water.† Second, on sinking deep

* The original state of the matter of our globe was probably once gaseous, perhaps like the comets, and composed of oxygen and hydrogen gasses only: one half of the base of flint (silica) is oxygen gas.

† Maskelyne used the plummet on Mount Schehalion in Scotland, to ascertain the weight of the earth, and Henry Cavendish leaden balls of different weights, suspended in a room, and observed how far the *larger* deflected the smaller, and he made it about $5\frac{7}{10}$ above water. Thus we find that the *density* of the earth, as a whole, is *twice* as much as the rocks composing its crust. From this fact some parties are of opinion, that the *metallic* bases of the earths and alkalies, occupy the interior of the globe in a *state* of fusion from intense heat. If this be the case, the disturbances on the earth's surface in past time, the present volcanic actions, and the *cause* of hot springs, may be more easily accounted for, as nothing can be more combustible than the bases of the earths and alkalies in that condition, by their *readiness to* combine with oxygen.

mines, we find the heat to increase the deeper we descend, namely, 1 degree in about every 50 feet of depth; this is also proved from sinking artesian wells. On sinking one at Grenoble in France, and after reaching the depth of 1657 feet, the temperature was found to be 79·5 of Fahrenheit, and at 1798, 81·7 of ditto. But the hot springs of Bath, (115 of Fahrenheit,) Buxton, (82,) Carlsbad, in Bohemia, (167,) and the geysers of Iceland, (180,) are sufficient evidence of the central heat of the earth. By bearing this fact in view, we shall be able to investigate the nature and character of granite, and of all the Plutonic rocks, with greater advantage.

SIMPLE SUBSTANCES.

The number of *simple* bodies, namely, substances which cannot be *reduced* by ordinary means to any other condition, is about fifty-five.*

Thirteen of these are non-metallic, as oxygen, hydrogen, silicon, boron, &c.

Eight earths and three alkalies, which have metallic bases, as potassium, sodium, calcium, aluminum, barium, &c.

Thirty-one metals, as gold, silver, iron, tin, arsenic, &c.†

* In Orr's Circle of the Sciences, No. 96, sixty-three simple substances are named, by adding niobium, norium, dorium, pelopium, &c. but which are little known, and only found in *chemical* combinations.

† Ten of these are found in their *native*, or simplest form, as gold, iron, silver, antimony, &c. The remainder *are found in combination* with other substances, oxydes, *&c. as, manganese*, cadmium, &c.

The consideration of the character and utility of all these substances, is the province of mineralogy and chemistry, only a very few entering into the composition of rocks, and these we shall now point out:

Silica, or quartz.
Calcium, or lime.
Alumina, (argil,) or clay.
Magnesium, or magnesia.
Oxyde of iron.

These are the only substances that enter chiefly into the composition of the rocky masses. The first of these, silica, enters largely into the composition of granite, syenite, &c. in its simple state; and the latter, iron, is universally diffused as an oxyde over the entire surface of the earth. It is to it, in the shape of clay iron-stone, as found in connection with the coal-beds, that we are indebted for that immense amount of iron, so absolutely necessary for the wants of our species.

CLASSIFICATION OF ROCKS.

Primary Igneous, or Plutonic Rocks.

Granite.
Syenite, or hornblend granite.

Metamorphic, or Altered Rocks.

Gneiss, or slaty granite.
Mica schist, or schistose rock.
Clay slates, or argillaceous schists.
Talcose schists.
Hornblend ditto.
Actynolite ditto.
Schorl rock.

Hypogene limestones, or the statuary and other marbles.
Serpentine.
Diallage rock.
Chlorite slate.

PALEOZOIC EPOCH.

Primary Fossiliferous, or Older Paleozoic.

Lower silurian series.
Upper ditto. ditto.

DEVONIAN, OR OLD RED SANDSTONE SYSTEM.

Cornstone, marl, &c.
Quartzos conglomerates, &c.

CARBONIFEROUS SYSTEM, OR NEWER PALEOZOIC.

Carboniferous, or mountain limestone.
Limestone shale.
Millstone grit.
Coal-measures.

PERMIAN SYSTEM.

Lower new red sandstone, or rothe tode liegendes.
Magnesian limestone.

SECONDARY EPOCH.

TRIASSIC SYSTEM.

New red sandstone.
Red marls.
Gypsum and rock salt.

LIASSIC SYSTEM.

Marls and clay.
Argillaceous limestone.

OOLITIC SYSTEM.

Lower oolite.
Upper ditto.
Middle ditto.

WEALDEN SYSTEM.

Purbeck beds.
Hastings sands.
Weald clay.

CRETACEOUS SYSTEM.

Gault.
Green sand.
Grey chalk.
Upper chalk with flints.

TERTIARY EPOCH.

Older tertiary, or Eocene.
Middle tertiary, or Miocene.
Newer tertiary, or Pliocene.
Drift, or Post Pliocene, or Pleistocene.
Recent, or post tertiary.

CHAPTER II.

GRANITE, SYENITE, AND METAMORPHIC ROCKS.

Granite is a crystalline rock, composed of three distinct mineral bodies, quartz, felspar, and mica. The first is nearly pure silica.* The other two are compounds.

* The flints *in* chalk, and most of the pebbles on the sea *shore, or forming* gravel beds, are also silicious, but *not so pure as* quartz.

We give below the usual composition of these two substances, they being so important as constituent parts of granite.

	*Mica.**	*Felspar.*
Silica,	46·3	66·75
Alumina,	36·8	17·50
Potash,	11·8	13·66
Lime,	0·0	1·25
Oxide of iron,	4·5	0·75
Fluoric acid,	0·7	0·0
Water,	1·8	0·0
Loss,	1·61	0·9
	100	100

Granite is the lowest known rock. Dig as we may, we never get below it; and it is also the highest. Dhawalagiri, the highest point of the Himalayan chain, is no less than 28,000 feet, or about 5½ miles in perpendicular height, and Mont Blanc is upwards of 15,000 feet, hence granite might be truly termed, the "pillars," or foundation of the earth.†

This rock is considered to be the first pellicle, cooled down on the earth's surface from an intensely heated state.

* Mica is sometimes called Moscovy glass, from being used for glazing windows in Moscow and other parts of Russia, where it is found in slabs of considerable size in the granite. It is extremely fissile, being easily divided into very *thin plates* or laminæ, and quite transparent, flexible, and not easily broken like glass. Talc is often mistaken for mica, but it is neither flexible, nor transparent, and also much softer.

† In the sublime language of Scripture it is said of the earth, *in Job ix. 6,* "*And* the pillars thereof tremble;" and *Psalm lxxv. 9,* "*I bear* up the pillars of it."

Granite differs materially in character in different localities; that from Cornwall is large grained, and part of it extremely liable to decomposition. Where the felspar is in *excess* the granite decomposes rapidly, and forms the fine porcelain clay used in the potteries.* This is unfit for building purposes; but the *fine-grained* granite of Aberdeen is the most durable building stone existing, and it is quarried extensively for this purpose. London Bridge is built of it, and wherever strength and durability are required recourse is had to this stone, for locks, piers, pillars, &c. and it is now worked up into vases, and other ornamental work for the drawing-room, &c. It is susceptible of a splendid polish, which is not easily acted upon by the weather.†

Porphyritic granite is so called by containing large well-defined crystals of felspar, in the form of parallelograms (some three inches long). This is finely exemplified in some of the slabs forming the pavement of London Bridge.

Waterloo Bridge is built of the *Cornish* granite, rather large in the *grain*, and any passer by may observe that the balustrades are, from being *weathered*, in a slow state of decomposition. Granite is of various colours, as grey, reddish grey, and dark grey, depending much

* About twelve thousand tons of this are used annually. This is similar to the kaoline of the Chinese, and called talcose granite, from its containing a quantity of talc.

† Pompey's Pillar is made of syenitic granite, and still retains its high polish, except on the north-east side, on which the fierce euroclydon (north-easter) acts with *great force during* the winter months; on that side it is *slightly* abraded.

on the mica, which is often of a light colour, with a brilliant pearly lustre, but sometimes *nearly black.*

SYENITE,

Or hornblend granite is a rock of considerable interest. Its name is derived from the village of Syene, in Upper Egypt, where it was quarried to a great extent in ancient times. Cleopatra's Needles, Pompey's Pillar, and other noted works are made of this stone, and they still retain their polish to the present day, although thousands of years have rolled by since they were erected. It has all the appearance of ordinary granite till closely examined, when a dark bottle-green-coloured substance will be perceived. This is hornblend, which occurs with the quartz felspar and mica, but it often *replaces* the *latter.*

The hills of Charnwood Forest are chiefly composed of syenite, and quarried for building and paving stones.* It forms a durable material for making and repairing roads. The superincumbent rocks (mica schist, clay slates, &c.) are often found penetrated with veins of granite and syenite, but more frequently with quartz veins. The other, or subordinate varieties of granite, need simply be named. That is, when either talc, chlorite, schorl, actinolite, &c. are imbedded in or connected with granite, then it is called talcose granite, schorl rock, and so on, but these

* *The streets* of Derby are paved with this stone, and *the London streets* are chiefly paved with the Aberdeen granite.

varieties are of limited extent and little importance.

METAMORPHIC, OR ALTERED ROCKS.

The succeeding rocks are so called, owing to the prevailing opinion that they have been *changed* by *heat*, and therefore originally mechanical deposits., hence the term metamorphic.

Gneiss is a variety of *slaty granite*, composed of the same substances, but of less extent and importance than granite. These substances are generally arranged in the composition of this rock *nearly parallel to each other*, hence its slaty appearance.

MICA, or micaceous schist, or schistose, is chiefly composed of mica and quartz. The greater part being mica it assumes a completely slaty structure, and having been formed on the disturbed or upheaved edges of the preceding rocks, it often appears highly contorted and twisted into the most extraordinary folds. It is sometimes found *full* of *garnets*, in the form of the dodecahedron, a twelve-sided crystal. Tourmaline, Beryl, and Corundum are also found in it.

CLAY SLATES.

The clay slates, or argillaceous schists, are of great extent and depth, and, as their name implies, contain a considerable quantity of alumina, (clay) or argil. Both quartz and mica enter into the composition of the slate rocks; when the *latter* prevails the slate assumes a *light or glistening* appearance, from numberless

minute specks of mica, and becomes fissile,* *easily* to be divided into thin plates or laminæ, fit for roofing-slates, which in North Wales are quarried to a great extent, so much so, that not less than four hundred men are employed, and thousands of tons of slates are shipped to all parts of the kingdom annually. These slates are of a bluish colour, sometimes with a tinge of red. They are also raised in considerable slabs of an inch thick, as flooring for warehouses, as they are easily cleaned if oil or other greasy matter is spilt upon them. The slates of Cumberland have a tinge of green, and an earthy appearance. They are coarse-grained, less divisible than the Welsh, but are of a more durable character. Hence they are preferable for buildings in exposed situations, which are intended to last for long periods, as churches, public buildings, &c.

Chiastolite slate is also found in Cumberland to some extent. It is so named from the mineral chiastolite being so abundantly distributed through this variety of slate.

Chlorite slate, of a fine green colour, may be named here as next in importance. The mineral chlorite is very generally diffused amongst all these rocks, and often found as a mineral coating and even in the interior too, of crystals of quartz. In the latter case it has frequently a very beautiful and ramified appearance.

* The fissile character or *cleavage* of the bed is frequently the *reverse* of its stratification; for instance, in *Wales the slates cleave* or *split* at an angle of 30 or 40 degrees *from the* plane of stratification.

CAMBRIAN AND CUMBRIAN GROUP.

These consists of a great number of greywacke slates, or schists, interstratified with shales and limestones, and contain a *few traces* of organic remains of encrinites, corals, and one or two species of bivalves;* hence the distinction made between these upper and lower slates. The officers of the government survey calculate the depth of all these measures at not less than 15,000 feet.

Remarks.

The lofty peaks of the granitic ranges are often inaccessible to man; they are either quite bare, or, at best, present a scanty vegetation. Indeed the whole group generally presents a remarkably dreary aspect, and it is only in the lower valleys between them that are fit for the dwellings of man, where vegetation, especially in hot climates, becomes luxuriant and beautiful. The springs which issue from thence are the result of the melting of the ice and snows of their immense glaciers, and do not proceed from faults and fissures, as is the case in the stratified rocks. Hence the Rhone and the Po have their sources in the glaciers of the Alps, the Brahmapootra and the Ganges in the Himalayas.†

These rocks are rich in precious stones, and ores of gold, silver, tin, copper, and other metals, most of which are found in veins, and consequently mined for, except gold and precious

* Found on the top of Snowdon.

† The *Ganges at its source* in the Himalayas, is a river *of considerable magnitude* as it flows from the glacier.

stones,* which are usually found in the debris, or sand and gravel, abraded or worn off from these rocks by the action of the elements during vast spaces of time, and washed down into the valleys by the torrents proceeding from them. Hence the gold diggings of California, Australia, Brazil, &c. In this we may see a wise arrangement of Divine Providence, for such is the hardness of the rocks in which the gold is embedded, that to quarry the rock and separate the ore, would have exceeded its value; but the destructive effects of time, cold, and heat, and the raging torrent, have placed within our reach the broken fragments of quartz rock, the gravel, and sand; so that at a small expense the quartz may be crushed, the gravel and sand washed, and the precious ore obtained pure.

SUBORDINATE BEDS—MARBLES, &c.

Upon the slopes of the Alps and Appenines in Northern Italy a variety of beautiful marbles are found, and worked extensively in some places; the statuary, (Carrara,) Sienna, and dove marbles are well known, and need no comment. There is also the Cipolino, a beautiful variegated marble, and some of the African are of similar character, one variety of which is of a fine green and whitish colour, the colours merging into each other like the green marble and serpentine of Anglesea.

* Diamonds are found in India in a red ochry clay and mud, in the river Mahanadi, from Chunderpore, where the river Maund joins the main stream, to Sohnpore, a course of 120 miles. Throughout this extent the dia[mond-searchers ply their trade, from the time when the] [rains cease, until their periodical return.]

The serpentine near the Lizard-Point in Cornwall is very fine, where also occurs a variety with brilliant red spots, now manufactured largely at Penzance, in Cornwall, into pillars, chimney-pieces, Cleopatra's Needles,* vases, and other ornamental works.

Amongst the ruins of Rome are fragments of a fine deep blood-red marble, called rosso-antico, and a yellow one not unlike the Sienna, named Giallo Antico, a black, Nero Antico, like the Derbyshire black, and a Verd Antique, of a cloudy green colour. These marbles are considerably harder than those of the same colour now obtained. Whether time has caused this it is impossible to say, for the quarries out of which they were taken are not known; but they all belong to the primary period, and are consequently given with the primary rocks.†

We have now considered, as briefly as may be, two classes of rocks—the Primary Igneous, and the Metamorphic, with their subordinates. And it will be found, as we proceed in the consideration of the stratified or mechanical rocks, that

* The variety with the red spots is admirably adapted for these needles, as the colour is not unlike the syenite, of which the original Egyptian needles are made.

† The porphyries, fragments of which are found with these, are also very beautiful. Two varieties occur, the red Egyptian and the green; the latter is the oophite of Pliny, but its locality is not known. "When distinct crystals of one or more minerals are scattered through an earthy or compact base, the rock is termed a porphyry. Crystals of felspar are usually embedded, but sometimes augite, *olivine*, and other minerals." But these are *eruptive rocks, and* will be noticed amongst the volcanic.

these two classes are of immense importance in the geology of the earth's crust; for it may be said, with only about one or two exceptions, (the mountain limestone and chalk,) that their *broken fragments*, and *abraded parts*, constitute all, or the greater portion, of the mechanical rocks; traces of them being found throughout their whole extent, either in the form of broken or rolled fragments, pebbles, gravel, sand, fine silt, or mud; everywhere may be seen quartz, felspar, or mica, sometimes in the minutest and almost inappreciable specks. All the grits and other sandstones—are evidently the result of their destruction by disintegration, abration, change of temperature, and the powerful agency of water during vast spaces of time.

Surely we may observe in this a remarkable instance of Divine Wisdom, in producing such a vast mass of crystalline rocks, as the first cooling result of the intensely heated matter of the globe, providing not only a basis for the superincumbent rocks, but also the materials for their construction.

MINERAL CHARACTER.

The granites may be known by their mineral composition of quartz, felspar, and mica, aggregated together, and forming one of the hardest of rocks. It is generally of a grey colour, very often of a reddish tinge, and sometimes it presents a dark aspect, from the colour of the mica, which is occasionally very nearly black, or blackish. *The quartz is* usually grey, very hard, and resists [redacted] *knife. The* felspar is of a pale pink, and

y be acted on, or scratched with the knife. e mica is always shining, or brilliant, *whatr* may be its *colour*.

Gneiss may be known from the granite, by assuming a kind of slaty structure, the comition being the same as granite.

MICA SCHIST, OR SCHISTOSE,

eadily distinguished by its slaty structure, and lliant, or shining aspect, being almost comed of mica. But this structure (slaty) is not result of mechanical action like the stratified ks, but may be considered the *result* of crysization, owing to the intense heat of the derlying granites.

Syenite is readily distinguished from granite, the addition of hornblend, which is of dark bottle-green, with a somewhat earthy ture. It often replaces the mica, especially the syenite of Charnwood Forest. It is excesely hard, and very difficult to be broken. e the granites, it nowhere presents a meanical or stratified structure, though frequently crystalline, but it is full of fissures, or joints, erywhere.

These fissures, or joints, no doubt, are the re t of the contraction of the rocks in cooling, er being upheaved to the surface, and exposed atmospheric action, and the removal of the st pressure to which the rocks were subjected at eat depths, beneath an ancient ocean.

When we consider the crystalline minerals, of hich *the granites* are composed, we may form *ne faint conception* of the fluid state of the

materials by intense heat, which allowed the atoms of matter to move freely, so as to form quartz in one instance, mica and felspar in another, and, ultimately, for these minerals to aggregate together with such force, and form one of the hardest and most durable rocks upon earth.

CLAY SLATES.

There is no difficulty in knowing the *slates*, both from the colour, the slaty structure, and earthy smell, when breathed upon, and also from their known utility as roofing slates. They have every appearance of being stratified, and may have been deposited like the mechanical rocks, and probably may have contained organic remains of some kind; but such was the *heated condition* of their base, or the rocks which they *overlaid*, that all traces of organic life, if they did exist, were destroyed, hence they are termed metamorphic or changed rocks. The organic remains we find in the upper series, or tops of the Cambrian and Cumbrian groups, do not at all militate against these suppositions. These remarks equally apply to *all* the subordinate beds of marbles. Even the pure white statuary, or saccharine marble, owes its sugar-like character to this cause.

"It is demonstrable," says Sir Charles Lyell, "in some cases at least, that such a complete conversion has actually taken place, fossiliferous strata having exchanged an *earthy* for a highly crystalline texture for a distance of a quarter of a mile from their contact with granite. In some cases dark limestones, replete with shells

and coral, have been turned into *white* statuary marble, and hard clays into slates called mica-schist and hornblend-schist, all signs of organic bodies having been obliterated."*

At this stage the pupils should be carefully examined as to the nature and character of these rocks; as to their mineral composition, crystalline structure, height, depth, or thickness; the absence of mechanical structure in the one class, (granites,) and its appearance in the other (clay slates, &c.)

It should be remarked that we can have no conception of the thickness of granite, because we have never cut *through* it. In mining operations we have often reached it, and sunk into it to considerable depths for silver, tin, copper, &c. but no *termination* of the rock has been reached. Nor can we discover its basset, for it has none, being purely crystalline. Nor is there any essential difference in its character, except it be from coarse grained to fine, and which is generally the *result* of the *slow* or *rapid rate* of its being cooled down.

But of the slates and other metamorphic rocks we have very distinct "BASSETS," that is, where the edges of the rocks come up to the surface, called their *culminating points*, or out-crop. Here, by calculating the *angle* at which they appear as nearly as we can, we have a *sufficient* proof of their thickness. It was by such means, as we observed in page 17, that the officers of the government survey calculated the thickness of the

* See "Lyell's Elements," 4th edition, p. 8.

Welsh slate system at 15,000 feet, or about three miles in perpendicular thickness, just as thick as Mont Blanc is in height. We may well be amazed at such stupendous operations, especially in so *small* a *fragment* of the formation of the earth's crust.

It will readily suggest itself to the mind of intelligent teachers what questions may be asked of their pupils.

CHAPTER III.

STRATIFIED OR MECHANICAL ROCKS — HOW FORMED—EFFECTS OF RIVERS—OCEAN CURRENTS—SUCCESSION OF STRATA, &c.

Before entering into the consideration of these rocks it will be necessary to explain the meaning of the terms STRATIFIED and MECHANICAL.

STRATIFIED implies a series of rocky* masses lying *parallel*, or *nearly so*, to each other, with *distinct lines* of *division* between them. These *lines* are generally indicated by very thin seams of fine mud, silt, clay, or shale, always different in their composition, or in some of their characters, from the rocks or beds they divide, and are often so *minute* or *thin* as scarcely to be visible to the naked eye. Where the rocks have been quarried, or exposed in a cliff or precipice,

* "By the term Rock in geology, is understood any *aggregation* of minerals, or fragments of minerals, whether *crystalline or amorphous*, hard or soft, compact or loose," *forming an essential* part of the earth's surface.

they there exhibit, by weathering, clearly defined lines of separation of one bed, or stratum, from another. *Weathering* simply means the *wear* and *tear* that all things are exposed to by the action of the elements. The cement, or mortar, used in a building, which gets washed out in time, from between the stones, may give an idea of this. But very frequently *without* the intervention of such seams, a *pause* or *cessation* of the deposits forming the rock, for a short *period only*, will occasion a compression and hardening of the *last layer*, so as to occasion a very marked line of division between one bed and another, whenever the rock gets exposed to the weather, it will more readily divide or split in that direction. If we pile a series of books of *different thicknesses* upon each other, and place between them a slip of very *thin paper*, it will help to give the pupil an idea of stratification, and of the thin divisions occurring in it.

A series of rocks thus stratified, or laminated, and not varying *materially* in their composition, is called a FORMATION,* as the limestone formation, the sandstone formation, and so on. But these numerous subdivisions are called *beds*, a familiar expression, the meaning of which is known to all.

MECHANICAL.—This term is applied to all strata which have been produced by the action of mov-

* The term Group, or Series, is often used instead of *formation*. Thus Professor Ansted has his lime group, sand group, and clay group—so designating the different *stratified rocks* in which lime, sand, or clay, prevail.—*See Ansted, p. 250.*

ing water, hence called aqueous. Evidences of this are sufficiently obvious to *all*, after heavy rains and storms—the muddy brook, stream, or river, with their varied contents of sand, silt, clay, or lime, washed down from the higher grounds, and deposited at *every turn* of the river where *stillness* prevails, or on its banks; and, when flooded, spreading its fine silt and mud over the adjoining meadows, which have been raised higher and higher from time to time, at each succeeding flood. But these effects do not terminate so near at home, or within our immediate observation: they are carried on, to an enormous extent, over vast spaces at the mouths of great rivers, such as the Ganges, the Mississippi, the La Plata, the Rhine, the Rhone, the Po, &c. and spread their contents over the bed of the ocean, forming sand-banks, mud-banks, and sometimes banks composed of both, arising from the difference of rocks and soils, of the countries through which the tributaries of these great rivers pass. It has been calculated that the Ganges brings down, and deposits annually, no less than 6,368,077,440 tons* in the Bay of Bengal. Our rivers, the Trent, the Ouse, and the Thames, with their tributaries on the *east*, carry

* "This mass of matter, thus carried down yearly, would equal, in *weight* and *bulk*, *sixty* of the great pyramids of Egypt; or, if we were to estimate the exertions of a fleet of about *two thousand* ships, loaded with about 1400 tons of mud, going down daily, and discharging this into the gulf, it would be no more than equivalent to the *operation of* the great river. The Burrampooter is considered to convey an equal quantity into the sea."—*Lyell's Principles, vol. 1. p. 364.*

vast quantities into their estuaries, and out to sea; as also on the west, the Irwell, and its tributaries, dispose of their contents into the Mersey, hence the dangerous sand-banks at the entrance of the latter river. The continued prolongation of the Spurn Point, stretching miles out to sea, at the mouth of the Humber, and the great accumulations at the entrance of the Thames, indicate clearly the effects produced by the action of rivers. The same thing is being effected, and perhaps to a much greater extent, by ocean currents, through the wear and tear of the strata by storms on the coasts, especially where the coast-line is composed of the softer rocks. For instance, on the coast of Suffolk and Norfolk immense quantities are being removed in heavy weather, while lower down, towards the Lincolnshire coast, the tidal current, which sets in from the north, is rapidly filling in, and silting up immense spaces * within the Lincolnshire Wash, and elsewhere. The Fens, as they are called, have been all recovered from the sea. It will be easily understood, too, that all such deposits will be fossiliferous, that is, contain organic remains, (recent.) For we know how various and multiplied are the forms of life existing in our seas and rivers, which die in succession, and become entombed at the bottom, forming, in course of time, large accumulations, either

* Many places on the east coast have been completely swept away, while others, once on the coast-line, stand now considerably inland.—See Lyell's Principles on Geology, *vol. 1. p. 393*; Phillip's Geology of Yorkshire, *and Taylor's Geology* of the east coast of Norfolk.

of marine or fresh-water fossils, or *both*, sometimes together, in an alternating series of beds. The latter circumstance will take place at the mouths, and within tidal rivers, or estuaries. During heavy floods, the fluviatile will be carried out to sea, or just deposited within the basin of the estuary, and the tide, especially during storms, will carry its offspring up the river. These actions taking place, at different and indefinite periods, will of course occasion so many different and alternating deposits of rocky, materials, and organic life. All these are the result of mechanical actions, which we hope are made sufficiently intelligible, so as to enable us to proceed in our examination of the ancient stratified rocks. In doing so, we have only to bear in mind that the mechanical operations, which formed these, were on a grander and more extensive scale than those now taking place in our present seas.

One or two considerations demand our attention before we proceed—namely, the position which we find these rocks to hold in relation to the underlying rocks. It will be obvious at once, to the reflective student, that we cannot expect to find them lying *horizontally*, but always more or less inclined, at an angle, from that of the horizon. This angle, in one place, may be only five degrees, but in others ten, twenty-five, forty-five; and some are so *tilted*, as to be nearly, or altogether, on end. The *lower* and less abrupt angles may be, and often [illegible], *owing* to the inclinations or deflections of the *rocks, on which* they have been deposited; *the more abrupt angles* indicate that those

measures have been lifted by subterranean or volcanic action. During which lifts, or disturbances of the strata, it often happens that the force exerted from beneath, will *differ* in *power* at various *points*, and occasion one part to be elevated above the other, hence the origin of breaks, faults, and dislocations of the strata. The same thing may be effected during such lifts, by part of the rock *subsiding* towards its original position. This last is often the case in limestone districts, which originate some of the caverns that occur in it.

THICKNESS OF THE EARTH'S CRUST.

We have already observed the effects of this arrangement, namely, that the strata will *emerge* on the surface at a given angle, according to the dip. (See page 23.) This is called the outcrop, by which we are enabled to measure pretty nearly the thickness of each of the stratifications, and which gives us a tolerable idea of the nature and thickness of the earth's crust from about ten to twenty miles perpendicular depth. This arrangement, also, is the cause of springs, and much facilitates mining operations, of which we have to speak presently.

But where these volcanic lifts take place *only* at one *given point*, then the strata will be elevated in the form of a dome, and will *dip*, or be *inclined*, at a certain angle, on three, if not the four sides of this dome. This is usually called a saddle, but when on four sides it is called a qua-qua versal dip.

The term dip will be understood to mean the

angle at which the strata *descend* or incline from the horizontal line. The direction of the bed is called the strike.

ORDER OF THE STRATA.

We have already observed that the most *perfect order* of superposition exists among the rocks. This has been ascertained beyond a doubt by a careful and laborious examination of the strata in most parts of the world, especially throughout Europe and America. The various kinds of rock are found to succeed each other in beautiful and regular succession, without the least confusion. As sure as we find the new red sandstone* in any given district, we shall find *next above it* the *lias*, and then the oolitic series, and beneath it, in Derbyshire, succeeds the magnesian limestone, and lower new red, and then the coal beds, and so on through all the different series, from the highest to the lowest. They are *never inverted.* It often happens that some of the series or formations may be absent in one place and present only in another, but whenever we find them *all* present in one place the succession is *regular* and *certain.* For instance, on the *east* side of Charnwood Forest, in Leicestershire, which is syenite, (a granitic rock,) the new red sandstone *lies* immediately *upon it*, and the slates connected with it, *without any intervening* rocks; but *west* of the Forest we have the carboniferous limestone first in order with grits and

* The midland counties of England are chiefly new *red sandstone.* To the south of it is the lias, oolites, &c. *To the north,* the coal and limestone districts.

the coal measures overlying the syenite and slates, and then the new red sandstone in its natural position. The same measures may be below the new red on the east side, but if so they are at some depth, and concealed entirely by the new red sandstone.

CONFORMABLE STRATA AND UNCONFORMABLE.

Whenever we find the strata resting on each other in regular succession, they are said to be *conformable;* but it sometimes occurs that the underlying strata may have been *disturbed* by volcanic or other agency, and turned almost on *end*, or, at least, lying at a very high angle. Rocks in such a position have been found overlaid by another kind of rock, in an almost horizontal line, deposited in tranquil waters subsequent to the disturbance. This is called unconformable. In Sir C. Lyell's "Elements," 4th edition, is an engraving showing a bed of red sandstone, slightly inclined, resting on *vertical schist*, at the Siccar Point, Berwickshire.

Some of the older limestones, (palæozoic) highly inclined, and perforated by *boring* mollusca,* are found covered with newer strata, nearly horizontal. This occurs at Autreppe and Gusigny, near Mons.†

Such facts as these bespeak a very high antiquity to the older strata, to be first formed, then

* Called "Saxicavous Mollusca," or stone borers, also called Lithodomi, or stone dwellers. Much of this limestone occurs full of holes, some with shells still inclosed, on a hill *near Ulv*erstone, Lancashire.

† *Sir* C. Lyell's "Elements," p. 61.

disturbed and upturned, subsequently perforated by shell-fish, (a slow process) and then covered over with new rocks, *each bed* of *both* having been deposited on the floor of an ancient ocean.

This certain order of the succession of the rocks is a matter of great importance in geology, for by it, in proceeding to examine a country, if we find one rock clearly developed, we may pretty nearly calculate what rocks are to be found *above* and *below* it, and such a discovery has led to the most important results in finding coal, iron, lead, and other metals, also the precious stones, &c.

The whole series of formations of which we are about to treat are generalized into three great divisions, namely:—

The tertiary, or upper formations.
The secondary, or middle.
The palæozoic, or lower.

All these are highly fossiliferous, and these fossil remains are a *decided test* as to the *age* of the rocks in which they are found, for the lower, or palæozoic, have a very distinct and marked character from those of the middle and upper series. And these, again, are subdivided into *groups*, equally marked as to their organic contents. The *mineral* composition of the rocks has been proved to be an unsafe guide, as a test of age, but the fossils *never*, so that a *general*, if not a special acquaintance, with fossils is absolutely necessary to the study of geology. We shall now follow the ascending order as we commenced, and then reverse the order by giving a tabular view at the end.

CHAPTER IV.

PALEOZOIC EPOCH.

Primary Fossiliferous, or Older Paleozoic.

SILURIAN SYSTEM.

The term silurian was first proposed by Sir Roderick Murchison, for a series of fossiliferous strata lying below the old red sandstone, and occupying a part of Wales and some contiguous counties, (Hereford and Salop,) in England, which once constituted the kingdom of the Silures, a tribe of Ancient Britons. The strata have been divided into upper and lower Silurian, and these again have several well marked subdivisions.

The Ludlow* formation is of considerable thickness, (2,800 feet,) and divided into four parts, namely, Tilestones, Upper Ludlow, Amystry limestone, and Lower Ludlow.

The tilestones are finely laminated reddish and green sandstones and shales. This division was originally classed by Sir R. Murchison with the old red sandstone, because they decompose into a *red soil* throughout the Silurian region; but at the same time considered it a *transition* formation between the two.

Upper Ludlow consists of a grey calcareous sandstone, decomposing into soft mud. Some of these sandstones are *ripple-marked.*† The tile-

* The town of Ludlow stands on this division, hence the name, so of the others.

† This is produced by the tidal current, especially when it is *somewhat* agitated, and is a common phenomenon *in sandbanks* of the present day.

stones which are extensively quarried, consist of a hard finely laminated and micaceous quartzose sandstones. The fossils usually found in these are Lingula cornea, Orthis orbicularis, Terebratula navicula, also species of Leptæna, Avicula, Trochus, Orthoceras, Bellerophon and others.* Also scales, spines, (ichthyodorulites,) jaws and teeth of fish of the genera Onchus, Plectrodus, and others have been found in these rocks.†

Aymestry limestone. This is a subcrystalline and argillaceous limestone, in some places fifty feet thick, and particularly distinguished by the abundance of Pentamerus Knightii. This genus of brachiopoda has *only* been found in Silurian strata. Three other abundant shells occur in this measure, the Lingula Lewisii, Terebratula Wilsoni, and Atrypa reticularis. Some of these beds form a tolerably durable building stone.

Lower Ludlow shale. These are composed for the most part of dirty shales, (a grey argillaceous deposit,) which readily decompose, forming a dirty mud, hence they are called mudstones. These are sometimes concretionary, which is formed on some organic body or other. They contain chambered shells of the genera Phragmoceras and Lituites. The latter is partly straight and partly convoluted, somewhat like the Spirula.

WENLOCK, OR DUDLEY LIMESTONE.

This has been long celebrated by its contained fossils. The well-known trilobites and the

* *Murchison's* Silurian System.
† *Lyell's* Elements, p. 352.

beautiful chain-coral, (Halysites catenulatus.) This formation forms a continuous ridge twenty miles in length, and is admirably exhibited in the rock on which Dudley Castle stands. Here the limestone has been excavated for a considerable extent under ground, to obtain the best of the lime fit for fluxing the ores of iron in the furnaces, which abound in the neighbourhood. These excavations form magnificent caverns. And it is not a little interesting to hear the splash of the oar, and the sound of the human voice, as the men navigate their barges through these dark regions.* Hugh Miller, in his "England and the English," has given a magnificent account of these remarkable excavations.

These measures are divided into large concretional masses of pure limestone, and abound with trilobites, the prevailing species of which are Phacops caudatus, and the Calymene Blumenbachii, (Dudley trilobite.) This latter is often found coiled up like a wood-louse.† We find also the Leptæna depressa, and two corals, besides the one already named; viz., the Porites pyriformis and Cystiphyllum Siluriense. The latter is so named from having *bladder-like cells*, from

* The Dudley canal traverses this hill through the line of caves, and thus with great facility they removed the limestone as soon as quarried. There are some fine walks to the old castle, and around Dudley hill, affording some beautiful views of the surrounding country, and these are quite free to the public.

† The word trilobite means *tri-lobed*, the animal being divided into three distinct lines lengthways. It is one of the *oldest* crustaceans,—their length seldom exceeds *three inches*.

two Greek words, κυστις, a bladder, and φυλλον, a leaf.* Graptolites are also peculiar to these rocks. The Wenlock shale sometimes exceeds 700 feet in thickness.

The Lower Silurian rocks have been subdivided into two varieties. Caradoc sandstone, which abuts against the trappean chain, called the Caradoc Hills, in Shropshire. Its thickness is estimated at 2,500 feet, and the larger proportion of its fossils are *specifically* different from those of the Upper Silurian. The upper parts of these beds are very variable. They are micaceous and thinly laminated, containing bands of impure sandy limestone, with occasional patches of pure lime. These are full of shells and fragments of the same. In the lower part of the group, a deep reddish purple sandstone mixed with clay, and marked with greenish streaks, occurs.

The base of the system, as recognised by Sir R. Murchison, in the Silurian region, consists of a hard, dark-coloured, sandy, or gritty beds, readily splitting into flagstones, and largely developed near the town of Llandeilo, in Caermarthenshire, and are thence called Llandeilo flags. The Plynlimmon and Bala rocks of North Wales belong to this part of the series. The Trilobites, Asaphus Buchii, Asaphus tyrannus, and Trinucleus,† occur in the flagstones, &c. also Grapto-

* See Lyell's Elements, p. 355.

† This family of crustaceans appears to have swarmed in the Silurian seas, just as crabs, shrimps, and other genera *of crustaceans* abound in our own. They had the *power of rolling* themselves into a ball, as a defence against *injury.—Lyell*, p. 358.

lites, Tentaculites scalaris, and annulatus; Orthis grandis, Pentamerus laevis, and shells of the genera Orthoceras, Nautilus, and Bellerophon; radiated animals, called Cystideæ, have been recently found in the oldest Silurian rocks.

Mr. Logan has also recently discovered footprints of chelonians in the lowest fossiliferous beds of the Silurian series, near Montreal in Canada.

OLD RED SANDSTONE, OR DEVONIAN GROUP.

This group of rocks has been called *Devonian*, because it is more fully developed in Devonshire than elsewhere. It was considered *un*-fossiliferous, till the late Mr. Hugh Miller first observed a peculiar and unknown variety of ancient fishes in the old red sandstone of Scotland, which he submitted to the inspection of Agassiz, who named them, at the same time declaring that these strange creatures (*mailed* fishes) just supplied the link hitherto wanting in the geological scale.* His book on the Scotch old red sandstone, called "*New Walks in an Old Field*," is deeply interesting. These measures are called the *Old Red*, in contradistinction to the *New Red*, which lies above the carboniferous system; the old lying under it, and forming its base.

By Sir C. Lyell the old red sandstone is divided into two groups, or series of beds.†

1st. A quartzose conglomerate passing down-

* These completed the link wanting between the Silurian rocks and the carboniferous.

† Elements, page 342.—1852.

wards into chocolate red and green sandstone and marl.

2nd. Corn-stone and marl, red and green argillacious spotted marls, with irregular courses of impure concretionary limestone, provincially called "Corn-stone."

Some of the former (No. 1) produce good paving-stones and coarse roofing-slates, especially in parts of Scotland, with impressions of marine plants, or fucoids.

The latter (No. 2) contain beautiful marbles as subordinate beds. The Babbacombe are well known, amongst which we find the beautiful coral called the feather-stone, or the Favosites polymorpha, which takes a fine polish.*

Mr. Miller, in his "OLD RED SANDSTONE" of Scotland, gives a section, in which he divides the Scotch series into three parts. The upper consisting of quartzose yellow sandstones, impure concretionary limestones, inclosing masses of chert and red and variegated sandstones and conglomerate. In these beds that remarkable fish, the Holoptychius, is found, with other characteristic fossils.

The middle consists of a grey fissile sandstone, in which is found the Cephalaspis, and other fossils peculiar to this division; and the lower is formed of red and variegated sandstones, undistinguishable often in their *mineral* character from the upper, but less gritty, and freer from pebbles. The next consists of bituminous

* *This is much* used for ornamental purposes, knife [illegible] *handles, inlaying,* &c. At Torquay these marbles are *great request* for such purposes.

schists, containing the Dipterus. Then succeeds coarse, gritty sandstone, and the great conglomerate forms the base of the whole, which, in Caithness, is found reposing on granitic gneiss. But in England, as shown by Sir R. Murchison, the old red reposes on the Silurian rocks, which are the next in succession in the geological scale.

In Devonshire this group consists, in most part, of green chloritic slates, alternating with hard quartzose slates and sandstones. Calcareous slates and marbles are sometimes found to lie interstratified with blue crystalline limestone and conglomerates, often passing into red sandstone. In North Lancashire, the deep red prevails, and occurs in immense masses of great thickness.* The old red sandstones of Russia "occupy a tract nearly as large as the British Islands, and they rest conformably upon low plateaux of Silurian rocks, attaining heights of from 500 to 900 feet above the sea level." In the county of Caithness, Mr. Miller states that they form a mountain-chain, which in one hill (Morrhiem) attains an elevation of 3,500 feet. The "Vans," or beacon-hills, of Caermarthen and Brecon, are the former, 2,590 feet, and the latter 2,500 feet. These hills are made up of a conglomerate composed of white quartz pebbles embedded in a red matrix.

We have been thus particular in giving a description of various localities, to show the rapid progress geology has made in a very few

* Furness Abbey is built of this stone. The old quarry close by it exhibits a steep escarpment, out of which the stone *was quarried* for it and the old Priory, now the *Abbey Hotel.*

years; for this group, so rich in some of the most remarkable fossil fishes, shells, and corals, was not only considered *un*fossiliferous, but confounded in its upper members with the mountain limestone, and in its lower with a *Grauwacke*, or transition system. For the fine Silurian system, also so well described by Sir R. Murchison, with its rare and characteristic fossils, had no place in any geological work thirty years ago, and yet these two systems have revealed to us the wonders of an ancient sea. The former, (Old Red Sandstone,) with its mailed fishes; and the latter, with its striking crustaceans, the trilobites, with their curiously constructed eyes, containing no less than four hundred lenses in each, besides great numbers of shells and corals hitherto unknown to the geologist. Well may Mr. Hugh Miller remark, that he who is content to stand still in geological investigation, will very soon be left far behind.

The scenery of the old red sandstone is often of a highly picturesque character. On the right bank of the Wye, north of Tintern Abbey, and between Monmouth and Ross, it is very fine. Mr. Hugh Miller describes it as presenting a bold and even grand and fearful aspect in parts of Scotland, particularly in Ross-shire, and in parts of Caithness and Orkney. Its compact sandstones form good building-stones, (largely quarried in the north of Scotland,) tile-stones, and roofing-slates. Paving-stones are also abundantly obtained; and some of its calcareous members produce good lime for manure.

The metals most abundant in it are copper

and tin in the veins which run east and west; but the transverse veins (north and south) produce lead, zinc, and some silver. (*See Ansted*, p. 435, ed. 1850.)

The ORGANIC remains are very remarkable.* We can merely name them. Of creatures of the fish class we have, the Pterichthys Milleri,† (winged-fish,) Cephalaspis Lyellii, (buckler-headed,) Coccosteus cuspidatus, (bull-headed, or berry-on-bone,) Osteolepis, Glyptolepis, (carved scale,) Cheirolepis, Cheiracanthus, (thorn-hand,) Diplocanthus, Diplopterus, Dipterus Acanthodis, (thorn-like,) and the gigantic Holoptychius Nobilissimus, a fragment of the jaw of which, in the possession of the Royal Society of Edinburgh, is 18½ inches in length, furnished with teeth, some of which are 5 inches in length. All but the latter are found in the lower members of the system, and are not bulky, the largest not exceeding one foot and a half in length, and the smallest only three inches. The Holoptychius alone, which is found in the higher members of the series, is of considerable magnitude compared with the preceding.

Mr. Miller, in his Old Red Sandstone, (second edition, 1842,) speaking of these strange fishes in his own possession, says, "Half my closet

* Old Red Sandstone, page 48, 2nd edition.

† "Eight species of Pterichthys (or winged-fish) are known. The singular fins, with their strong points and oar-like blades, were weapons of defence, which, like the occipital spines of the river bull-head, (Cottus Gobio,) were erected in moments of danger or alarm; and at others, lay close to the creature's side, the tail being the *sole instrument* of motion."—p. 48.

walls are covered with the peculiar fossils of the lower old red sandstone; and certainly a stranger assemblage of forms have rarely been grouped together; creatures whose very type is lost, fantastic and uncouth, and which puzzle the naturalist to assign them even their class; boat-like animals, furnished with oars and a rudder; fish plated over, like the tortoise, above and below, with a strong armour of bone, and furnished with but one solitary rudder-like fin; other fish, less equivocal in their form, but with the membranes of their fins thickly covered with scales; creatures bristling over with thorns; others glistening in an enamelled coat, as if beautifully japanned, the tail, in every instance among the less equivocal shapes, formed, not equally, as in existing fish, on each side the central bone, but chiefly on the lower side, the bone sending out its diminished vertebræ to the extreme termination of the fin. All the forms testify of a remote antiquity—of a period whose 'fashions have passed away.'"

SHELLS.—Megalodon cucullatus, Calceola sandalina, Clymenia linearis; also, Orthis, Spirifer, Atrypa, Productus, and Strygocephalus Burtini. This latter, with the Calceola, are exclusively Devonian fossils.

CORALS.—Cyathophyllum cæspitosum, Porites pyriformis, and Favosites polymorpha; also, a species of Trilobite, the Brontes flabellifer.

Chelonian foot-prints, and a reptile called Telerpeton Elginense, have been discovered in *the old red sandstone* of Morayshire, near Elgin. *Forfarshire*, impressions of plants and eggs

of Batrachians have been discovered, also *rain* drops and ripple marks, which show the effects of oceanic action below, and of heavy storms of hail and rain from above, in an ancient world.

The old red is largely developed in Herefordshire, parts of Shropshire and Worcestershire, South Wales, North Wales, Devonshire, North Lancashire, Cumberland, and very extensively in Scotland; also, in Russia, North America, &c. It forms the base of the great coal field of Scotland, and part of that of South Wales, where only a thin band of limestone separates it from the coal. Wherever its upper beds of shale and clay prevail on the surface, it is highly productive, as is seen in the splendid orchards and rich fields of Herefordshire; but in those localities where the harder and more compact sandstones prevail, it is often barren and heathy.*

CARBONIFEROUS, OR MOUNTAIN LIMESTONE.

This System includes the Mountain Limestone, Limestone Shale, Millstone Grit, and the Coal Measures.

Some of the most picturesque and beautiful scenery in the world is found amongst the rocks and hills of this formation. Who has not heard

* The thickness of the old red sandstone as estimated by Sir R. Murchison, is not less than 10,000 feet.

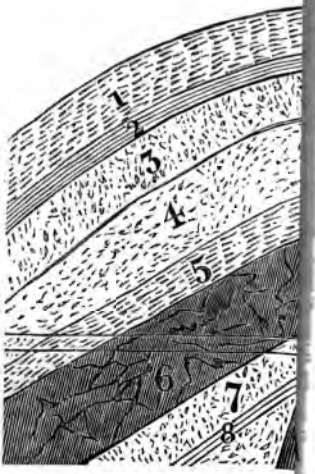
The link supplied, observes Sir Charles Lyell on this system, by the whole assemblage of imbedded fossils, connecting, as it does, the paleontology of the Silurian and Carboniferous groups, is one of the highest interest, and *equally* striking, whether we regard the genera of *corals or of shells*. The *species* are almost all distinct.

of the bold tors and fine dales of Derbyshire? The High Tor especially raises its bold head perpendicularly 400 feet from the bed of the Derwent, which laves its base. Chee Tor, five miles below Buxton, rears its noble crescent form about 300 feet above the sparkling waters of the Wye; and Dovedale, with its lofty hills, exhibits pyramidal forms and massive wall-like sections, as if they had just started from its bold and precipitous sides. The Cheddar cliffs in Somersetshire, and the Wynd cliff on the banks of the Wye, (South Wales)—the Yorkshire dales, with their fine limestone scars, some of them above 300 feet high—Leyburn Scar, in Wensleydale, on the course of the Aire near Skipton, and on the Ribble near Clitheroe—parts also of Cumberland, Lancashire, Flintshire, and Glamorganshire, and in Ireland about Sligo and Inniskillen—all these exhibit the fine features of the limestone so tempting to the tourist and the artist. On the Meuse, from Namur to Huy, exhibits some imposing sections. And the hallowed and sweet scenes about Jerusalem, the *hill country* of Judea, and the lofty rocks of the Kenites and Edomites, who anciently made their nest on high,* owe their beauty and picturesque character to this formation.

The CAVES of the limestone are equally remarkable and imposing. The noble caves of Castleton, Peak Cavern, and the Blue John Mine, Poole's Hole, Buxton, the interesting caves

* *See* "Nest in a rock."—Numbers, xxiv. 21. "In the *clefts of the rock.*"—Obadiah, i. 3. "Nest as high as the *eagle.*"—*Jeremiah*, xlix. 16, &c.

SECTI



High Tor Tunnel.

1 Chert Measures; chert and y
alternating, fifty feet thick. th
2 Entrochi Marble Bed, twelve
containing quantities of fossil sh y
3 First White Limestone, inte
numerous calcareous spar veins et
4 Limestone; also called the *firs* w
divided from the upper by an
clay. This bed contains numer ch
of flint. It is sixty feet thick.
5 The Second Chert measures, wit d
eye Marble and Dunstone, 36 f

N.B.—It will be observed that he *south side* of the Tor. But whether th *side of the fault*, is not shown. Th

of Matlock, the numerous caverns in the neighbourhood of Ingleborough and Nidderdale, the caverns of Germany and India, the cave of Engedi in Palestine,* the beautiful stalactitic one of Antiparos in the Archipelago, Adelsburg in Illyria, the caves and grottos of Nettuno in Sardinia, and the "Mammoth" cave of vast magnitude in North America, are all interesting and instructive examples of limestone caverns.

Into similar caverns the waters of streams and rivers often become engulphed. The entire drainage from the limestone basin beyond Mam Tor (Castleton) and the Winnats on the road to Buxton, is engulphed at Perry Foot, and traverses through part of the Blue John Mine, Speedwell Level, and the Peak Cavern, and then issues from a vein in the rock a little below the mouth of the Peak Cavern, a distance of three miles. Those of the Hamps and Manifold, in Staffordshire, fall into caverns, one near the Waterhouses, midway between Leek and Ashbourne, and the other near Ecton, and emerge, within fifteen feet of each other, near Ilam Hall, by Dovedale, a distance of six miles. The river Aire loses itself near Skipton, not far from its source, and passes for a considerable distance through a subterraneous passage, and again issues at the foot of Malham Cove, a perpendicular limestone rock 288 feet high. Throughout every part of the world where the limestone appears, it generally exhibits similar characters; and the reason

* The caves of Machpelah, Makkedah, and Adullam, are also *in the limestone*. See Genesis, xlix. 30; Joshua, *x. 16; 1 Samuel,* xxii. 1; 1 Samuel, xxiv. 1.

is obvious, from the fact that the limestone consists of a solid, highly compact, and crystalline substance, in many districts of great thickness, with only very thin partings of clay or shale between the beds. Hence, when upheaved by volcanic agency, and that force often acting unequally in its power, large masses of the lime would be lifted unbroken, the more fractured parts falling back, and leaving the larger resting on walls of limestone, and so forming capacious openings. In some cases, large fractures would occur from similar causes, forming rake veins and pipe ditto;* all these partly modified by the agency of water. But still, so hard and tenacious are some of the limestones, that the fractured edges, both above in the exposed rock, and below in the cavern, are little affected by time or the action of streams of water, being almost as sharp in their outline as when first broken; their opposite angles and clefts showing, that if they could be moved back into their original position, they would fit with the greatest nicety.

The carboniferous limestone is so called because it is sometimes found alternating with true coal, and sandstone beds and shales, as in parts of North Yorkshire, and in Scotland. But in other parts of Yorkshire, about Skipton, and in Derbyshire, it occurs in enormous beds of great thickness, where a series of shale and gritstone measures set on between it and the coal from 4 to 600 feet thick. But in some places, where

* *The rake* comes up to the day, or to the surface. *The pipe does not*, but hades (inclines,) as they term it, *having a roof* and sole, or floor.

the grit and shale beds alternate with each other, it amounts to no less than 900 feet, as in Mam Tor* and the hills north of Castleton.

In Wensley Dale (Yorkshire) the limestone alternates with freestones and flagstones, perhaps 1000 feet in thickness. This is on the north-west side of the dale, while on its opposite, the bold limestone mass of Leyburn Scar occurs in great force. In the fine micaceous flagstones of this dale we find the large marine worm, or annelide, some of them not less than 8 feet long; also another creature, like a worm, bull-headed, not yet named, of much smaller size, occurs frequently—not a slab I saw divided, but what contained many of them.

The carboniferous system of Devonshire is represented by a vast thickness of culmiferous measures, consisting of sandstones and indurated shales, (the latter containing the culm,) the thickness of which has not been ascertained. The sandstones are generally close grained, of a greenish-grey colour, passing occasionally into flagstones and laminated arenacious shale, with fine ripple marks at the partings.

We will now consider the Derbyshire series more particularly, as it contains the interpolated Traps, or Toadstone beds, which have so long puzzled the geologist as to their number. To do this with sufficient clearness, we have specially examined a section of the long-famous High Tor seen in the diagram at the beginning, the top beds of which consist chiefly of hard, grey and

* *The Shivering* Mountain near Castleton.

dark limestones, alternating with regular bands of black chert, which sometimes occurs in large compressed lumps. Indeed all the chert appears compressed, or flattened, giving no indication, or but slightly, of its origin, like the flintstones in the chalk in the south of England, to which it has been compared in some respects; but there can be no doubt that cherts have an origin similar, arising from multitudes of sponges, and myriads of infusorial animalcules, which existed in the ocean at the time of its formation. The limestone occurs in beds of about a foot in thickness, and pretty regular, except where a thick lump of the chert occurs; then succeed a bed of chert, seldom more than three inches in thickness, and these limestones and cherts are pretty regularly repeated to the depth of fifty feet. Then succeeds twelve feet of grey entrochal marble, sometimes flaggy,* but generally presenting fine blocks of great solidity and thickness, quarried in many parts of the Peak of Derbyshire, sawn into slabs, and made into chimney-pieces, which are sent to all parts of the kingdom: columns, &c. are also made of it.†

North of Matlock, at Bakewell, the cherts assume a different character altogether. In the

* Out of one of these divisions was obtained a slab about twelve feet by eight, which was sawn and polished at the Ashford Marble-works; then sent to Chatsworth, and mounted on a richly gilt stand, where it forms a magnificent table in the centre of the Great Hall.

† *The magnificent* architraves, entablatures, and door-*facings of the dining*-room and sculpture-gallery at *Chatsworth, are formed* of this marble.

large quarry just out of Bakewell, to the left of the Ashford road, hundreds of tons are annually removed into the Potteries under the term of *China Stone*, and used after calcination in making china ware. The beds in this quarry are six feet thick, (one at least,) and of a very light colour, compact and crystalline, sometimes porous and spongi-form.*

Beneath this, a bed occurs one yard thick,† literally filled with producta, spirifers, some terebratulæ and orthoceratites sparingly, the limestone appearing in some places only as a cement for the shells.‡ Thin partings of clay occur between the chert and the marble, also between the marble and this latter bed.

* The author, when examining this quarry with Professor Johnson, was led to observe a piece of limestone containing a flint decidedly similar to those in the chalk, which may strengthen the idea generally obtaining, of a similar origin to that of the flints in the chalk. The mode of getting these hard cherts may be interesting to the reader, to show the way by which they are broken up ready for carting.

The six-feet chert bed rests immediately upon a three-feet limestone bed, which is worked out from under the chert by little and little, the men propping up the chert as they proceed onwards, at intervals, with pieces of limestone, till they have undermined the chert from three to four feet inwards, and from ten to twenty yards in length. The whole, having only such slight props, ultimately gives way, and topples over, and, as the quarry-men say, "the chert *gets itself*."

† This bed is included in the twelve feet named, p. 48.

‡ The encrinital stems which occur in the chert, by being weathered, are converted into what is termed "*screw-stones*;" and in the marble, by the same process *into "St. Cuthbert's beads."* In the first instance, the fo

The first white limestone succeeds these marble beds. It is a greyish white, called by the miners the "first white lime," the top member of which is thirty-six feet thick, and is divided into three compact sub-crystalline beds, two of eight feet each, and one of twenty feet, in which a few oval patches of chert occur, one foot by seven inches over, but very few shells. Then comes the 8-inch clay bed, the first important clay in the series, it divides the upper from the lower, or next member of the first white lime.

This lime is about sixty feet thick, and in five divisions, with thin partings of clay between. The thickest is seventeen feet, and the thinnest seven feet. It is also a compact, greyish, semi-crystalline lime, containing a few patches of chert, and a few shells and corals, very sparingly.

At the south end of the Tor the sixty-feet bed rests immediately on the first toadstone; but at the north end, not half a mile distant, a new series of beds sets on between the preceding and the toadstone of thirty-six feet.* Whether they ever existed at the south end, and were eventually

decays, leaving the matrix alone, while in the latter the limestone gives way, and consequently leaves the fossil free. In limestone districts where the latter occurred, they were used for rosaries by the priests and their devotees centuries ago.

* In the north end tunnel, between these and the upper beds, a short seam of tolerably good coal occurs, which, in the middle of its course, was six inches thick. It did not extend beyond one hundred yards, but *feathered, or* died out at each end. Something similar *may be seen in* the roof of the level of the Rutland Cavern, Matlock Bath.

carried off (denuded) by oceanic currents, it would be difficult to determine. But any one who has seen the sea-shores, or estuaries, at ebb-tide, and observed the numerous sand or mud-banks, with channels between, (often the current-stream,) and then reflected on the fact of a storm setting in at the mouth of the estuary, or on the coast, as the tide flows inwards, will have no difficulty in seeing that a sand or mud bank, or one part of it, might be swept away by that current-stream, aided by the overwhelming action of a violent storm. Such changes are frequently taking place in our present seas from such causes, and we merely give it as a supposed reason why such a difference exists in the High Tor beds at so short a distance. We shall now name these. First, we have a second chert series occurring, with hard, dark limestones alternately, but each bed thinner than those of the first series, and the cherts more continuous, or less broken; a hard, dark, laminated limestone succeeds, coarse grained, and slightly twisted.* Then a series of six hard black beds occurs, often siliceous, containing myriads of minute encrinital stems, with, occasionally, the Cyathophyllum turbinatum,† and numbers of Producta distributed through it.

* This produces the purest and best lime when burnt.

† Where these beds are found free from chert, which is sometimes the case, they are quarried, the blocks sawn into slabs, and manufactured into chimney-pieces, and other ornamental work, under the name of the Bird's-eye Marble, *at Bakewell*, (Lomas's,) and Ashford Marble *Works.*

The magnesian limestone, locally called *Dunstone*, lies beneath the preceding. It is of a dun, or dark drab colour, arenaceous, and liable to decompose, when decomposed it becomes yellow. It is very different from the magnesian limestone of the Permian system, being useless as a building-stone. It is of limited extent, and contains few fossils; a Tubipora, and one or two Bivalves not named, are all that have yet been found. Wherever it is found, it always overlies the first toadstone. In the Tor, however, (north-end tunnel,) a very thin bed (one foot) of very hard black marble occurs between it and the toadstone clay, which takes a fine polish, and is full of yellow iron pyrites.

We have now given, as occurring in the High Tor, and generally throughout the Peak, the various chert and white limestone measures which repose above the toadstone. There is, however, one remarkable exception to such a series of beds, for between Ashford Marble Works and the south opening of Monsall Dale, at a sharp angle of the road, where a bold cliff of the toadstone appears, an enormous series of dark, bituminous limestones (bad black marble) is seen to rest immediately on the toadstone without any of the white limestone. And this series of beds, amounting to several hundred feet, (not less than 500,) are all very thin beds, from three to twelve inches, with slight beds of shale and black chert alternately occurring between them. *It is just* in this series of rocks that the finest *and purest black* marble is obtained at Ashford. *This formation,* together with the shale or shiver

bed,* as it is sometimes called, occupies the whole valley and hill sides of the neighbourhood of Ashford.

TOADSTONE.—The first toadstone succeeds, and is, with its under and upper clay beds, ninety-six feet thick, with only one apparent divisional line occurring in the middle, as if it had been thrown out of its volcanic source at two different periods. It exhibits no bedding, but is full of fractures. These fractures generally run in slight curves throughout the mass; and on close examination, we find they are the termination of immense five-sided crystals,† every side of which, where perfect, is above five feet across. The whole mass, as seen in the south-railway cutting of the High Tor, is thus sub-crystallized with thin veins of fibrous calcareous spar, and sometimes actinolite occurring in it. In this section no AMYGDALOID occurs, perhaps showing that it was thrown out under high pressure. It is also very slightly seen in the north-end tunnel of the Tor.

But in the second toadstone of the opposite, or Masson side, where it is largely developed, the amygdaloid appears. This, however, is always confined to the upper part of the bed, not distributed through its whole depth. Hence this part of the second toadstone must have been

* So called, from its extreme liability to decay and crumble to pieces. The destruction of Mam Tor, or Shivering Mountain, near Castleton, is entirely owing to this character.

† In blasting the toadstone, it often occurs that smaller crystals variously modified leap out, which, when broken, invariably *contain* an oval or round mass of very hard *toadstone. This* is called the *Whinstone* boulder.

thrown out under slight pressure, and cooled down while the gases and air still occupied the cells in the heated mass.* All this being covered over by beds of limestone, the cells would, from the effect of time and pressure, become more or less filled with lime by infiltration.

This great igneous, or trappean bed, interpolated between the limestones, has a six-feet clay above, and a four-feet clay beneath it. On the south-end of the Tor, the clay is of a fine yellow colour, and plastic, sometimes of so fine a yellow, as to be used for colouring the house-fronts; but it is generally of a bluish colour. On the north-end, however, this clay is of a far different character. It there assumes a greenish tinge, and is partly compact, filled in with green-stone boulders, about the size of a cannon-ball, and loaded with brilliant yellow-coloured pyrites, (a sulphuret of iron.) Hence the foolish idea that this was gold ore, which occasioned such a stir a few years ago. It is slightly, and only very slightly, auriferous.†

* These cells, or openings, no doubt have been filled in by filtration, from the overlying limestone bed. The cellular stone, as it is called, is either the result of being unfilled, or from the destruction of the lime it contained by exposure when the toadstone was broken up, or upheaved, and exposed to atmospheric action.

† Some years ago, a miner of Snitterton, near Matlock, obtained a small potful of this ore, which he took with him to London in one of his journeys, in order to have it analyzed by a chemist in the city, who knew as little *of its nature* as himself. When he had put it into his cru*cible, and exposed it* to a powerful heat, lo and behold! *this supposed gold* vanished into smoke, leaving only a

The under clay bed is four feet thick; about two feet of which has a compact slaty structure, and is of a deep green colour (green-stone.) The remaining two feet are various, but chiefly consist of plastic clay. There is not the slightest trace of organic remains in the toadstone, which obtains this unsavoury cognomen in Derbyshire from its dark, dirty colour; in many places it appears not unlike the colour of the toad's back.

SECOND LIMESTONE.

The limestone between the two toadstones is of considerable thickness, being 112 feet, and of one uniform, sub-crystalline texture of a light grey colour, and not cherty. It contains fewer organic remains than the upper measures. This is divided by clays, of more or less strength, into nine beds; the thickest about twenty-one feet, and the thinest three feet. This latter is the top bed next to the toadstone, and has been evidently changed, or charred, by the intense heat of the toadstone as it flowed over it. It is of a bluish grey, and ferruginous, and separated from the succeeding beds by a nine-inch clay. In Tideswell Dale this bed is replaced by a fine compact coralline limestone, which is quarried, and used at the Bakewell marble-works for chimney-pieces, slabs, &c. It takes a good polish. About forty feet below this a bed occurs, two feet thick, quite crammed full of Terebratulæ, which may be

dirty black scoria behind. In fact, being a sulphuret, the sulphur was driven off, leaving the pure iron. Even so do *our golden* dreams vanish into thin air, leaving not *a trace behind!*

termed the Terebratula bed;* then succeeds a six-feet bed, containing corallines, particularly the Cyathophyllum basaltiforme (basaltic-formed coral.) Next succeeds the "great clay," as the miners term it; this is in contradistinction to the "little clays," one of which occurs above, and another below it, of about three inches thick each, these are the miners' three clays,† and their chief guide when sinking in deep measures. The top part of this great clay, two feet thick, is a very hard, bluish pebbly clay, the bottom is highly bituminous, and full of broken producta.

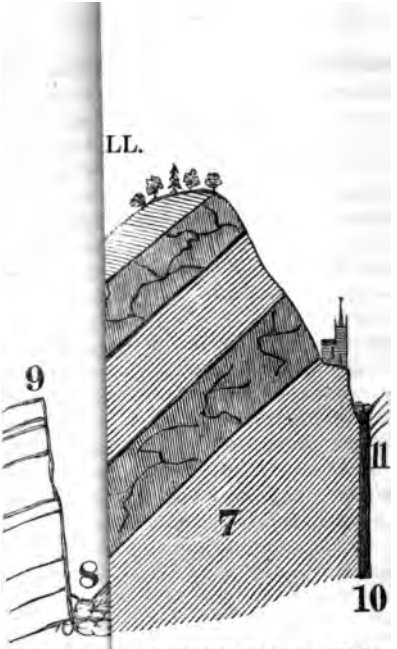
The remaining forty-eight feet is pretty uniform till we come to the last few feet just above the second toadstone-clay, in which minute and very minute encrinital stems occur, quite as small as those existing in the second chert measure above the toadstone, (see page 51,) and accompanied, also, with small Terebratula.

SECOND TOADSTONE.

Here we come to a *Second Toadstone.* Of this there can be no question, for the same bed, answerable to the opposite one on Masson side, is thrown up no less than fifty feet, and it appears to have a clay bed of six feet thick, like the one above the first toadstone. On the Tor side, by the grotto, this second toadstone shows itself to

* In some places this bed contains large producta, which is the case in the quarry opposite the Tor. Indeed all the beds differ at times materially in different parts of their course, often dying, or feathering out altogether.

† *All the limestone* clays of which this large one is the *chief, are locally* termed "wayboards."



1 Chert me[illegible]stone, developed about 80 feet
2 First whit[illegible] church in Bonsall village.
3 Magnesia[illegible] in High Tor Dale.
on Mas[illegible]
4 First toad[illegible]lt.
5 Second li[illegible]*pper* limestone measures, west
6 Second to[illegible]l fault.

This sketch[illegible]n, overlooking Matlock Bath,
and also the [illegible]

the amount of twelve feet only. I have seen and examined both their bassets. The first throws itself out on the top of Masson Lowe, and covers its entire top, with only a slight capping of Dunstone (magnesian limestone) on the east side. The second toadstone basset is seen in the lane some hundred yards above Bonsall Cross. The measures thus exposed exhibit a section of upwards of 500 feet, therefore, I believe, this second toadstone has never been cut through, since there is, with one exception, no mine on Masson or in the neighbourhood, where all these measures are on, which is more than 100 feet deep.

In sinking a mine-shaft on a fault, and with a hading vein, I mean one dipping at a considerable angle from the horizontal line, such a shaft, of course, would first cut through one side of such fault and then the other, and if the displacement was considerable, say thirty, fifty, or sixty feet, the miner would naturally come to the same bed again, and, without knowing, call it a second, or a third toadstone, as the case might be. Hence most of the miners name a third, and even a fourth toadstone, as occurring, and all the old works on Derbyshire mining adhere to the same misstatements. But we beg to state that only one toadstone has ever been pierced at Castleton, Buxton, &c. and yet one mine, the Slitter-gate, has been sunk to the depth of 600 feet without reaching a second, so that two beds are not universal in the Peak.

The top bed of this second toadstone in Masson is amygdaloidal, a good section of which may be seen behind the late Mr. Robinson's house opposite the High Tor.

Very recently the author has discovered the basset of a THIRD LIMESTONE under the second toadstone in Bonsall village, just below the church, where a bold cliff appears, and which has been till now considered as belonging to a higher measure, but thrown down into its present position by a fault. It is full of Producta, Terebratula, and some fragments of encrinital stems, which latter induced the belief of its belonging to the marble bed higher up in the series. This is not the fact, for it is clearly overlaid by the second toadstone, and is developed at least eighty feet. This is the only place as yet known where all these measures can be distinctly traced one above another.

We have been thus particular in describing the limestones and toadstones of Matlock, because the subject has never been fairly laid before the public by any writer.

These limestones have been stated to be about 900 feet thick, but we have only made out 580. This difference we shall find by looking westward to their out-crop. The same measures of which we have been speaking, are evidently propagated westward in undulating hills and a high limestone basin as far as Dovedale; for there the same limestones occur, but without any toadstone. Beyond this, about five miles still to the west, we have the out-crop of the deep ferruginous lime in Caulden Low Quarries, so extensively worked for limestone for fluxing,* also to the

* *Four hundred* tons are sent off per rail to Great-*Bridge every day, for* the smelting works in Staffordshire, *for the iron forges,* &c.

north in Ecton Hill* (1,500 teet high.) All these are deeper measures, and may well express the amount of 400 if not 500 feet in thickness. Hence I take the whole limestone series of Derbyshire, and part of Staffordshire, to amount to 1000 feet; and yet some of the beds composing this great amount are little more than a sixteenth of an inch thick. A small bit of the weathered part of Ecton Hill I have by me of such thinness. If this does not express a high idea of the immense periods of time it would take to accumulate such a mass of beds a *thou sand feet*, all full of shells, corals and encrinites, each bed being the floor of an ancient ocean, on which lived and died myriads of these living creatures, I know not what can express long periods of time. And yet this is considered by the geologist as but a small coral reef, only twenty-two miles east and west, by about twenty-four south and north.

The High Tor is what is termed a *saddle*, the measures dipping from the crown each way, south and north (see diagram;) but the real dip is to the north-east. This is seen to be so beyond the Horse Tor, which takes an easterly direction; and the whole of these measures terminate in a low cliff overlooking the river to the north, where they exhibit a finely curved section. But the most remarkable limestone curve, or

* Ecton Mine has produced vast quantities of copper. It is said that the late Duke of Devonshire, to whom the mine belonged, obtained £10,000 per week for some months, *but it is* now very poor. The shaft is fifteen *hundred feet* deep.

series of curves, is in Ecton Hill, on its north-east angle, about two and a half miles beyond Hartington (Ape Tor.) There the measures are turned over, one upon another, and some nearly on end, showing the most beautiful flexures.

The marbles belonging to the Derbyshire Limestones have been long known, particularly the black and entrochal marbles.

THE BEST BLACK is found only in the neighbourhood of Ashford, but the ENTROCHAL is more generally distributed. There are good quarries near Monyash, in the High Peak Railway cutting, near Wirksworth, and in the Pig Tor, near Matlock. This bed dies, or feathers out into a dark, shaly bed in Middleton-Dale, (Stoney Middleton,) and some other places.

The Rosewood Marble is a silicate of lime, and very hard. The configurations on the marble and the colour, nearly approximate to rose-wood, hence the name. It is found near Ashford.

The CORALLINE Marble is sparingly distributed, but often found in the chert measures, and sometimes connected with the entrochal marble bed. It occurs in patches generally. In a quarry near Matlock, it appears to replace the entrochal bed, and some good blocks have been obtained for chimney-pieces. It is of a reddish colour. In the limestone of North Lancashire it is strikingly exhibited on the shores of Ulverstone Bay; one patch of it appeared on the limestone floor of the bay, washed by every tide, exactly like a bush, with a spreading top, terminated by a common root attached to the rock, all, of course, now imbedded; but once this

bushy head lived and perhaps moved to and fro in the ocean.

Beautiful red (Rosso Moderno) and brecciated marbles are found at Parwich and Newhaven, on the Duke of Devonshire's property; also Bloodstone, (Hileatrop,) Jasper, and Dendritic Marble, but these are all of limited extent.

Vast quantities of lead ore (a sulphuret) have been found in the limestone mines of Derbyshire and Yorkshire. In the former large cross veins occur, filled with oxyde of iron; the softest is worked for the mineral ochre. One vein in North Lancashire is worked extensively for this iron ore; no less than 350,000 tons are sent annually over the Furness Abbey Railway to Peile and Barrow, to be shipped for South Wales, where it is converted into malleable iron, as the ore cannot be fused in the neighbourhood for want of coal.

The lead mines in Derbyshire have been very productive. Even two thousand years ago the Romans worked these mines, and have left many evidences of their presence in their mode of working, and the tools left behind them. The High Tor veins were, some years ago, very rich in ore, but are now entirely worked out. The Crich mines have been by far the richest of late years, many hundred thousand tons having been found in that isolated and dome-like hill.* When the Wakebridge Mine was first worked, and the men had come upon what is termed a *lode* of *ore*,

* It is separated from the limestone range by the gritstone. No doubt it has been thrown up with great force *through* all the gritstone measures into its present *high position.*

(mass,) the proprietor was offered £10,000 for the ore *on sight* in the vein. These mines are not now so profitable. The mines of Eyam have been likewise very productive; and also the Old Gang Mine on Cromford Moor.

We may remark here, that all the mines which have produced the most ore, are on the line or margin of the limestone and gritstone, (at their junction;) or, as it may be expressed, they are just on the *axis* of *disturbance* between the two; all, or most of the best mines, having a capping of shale and grit above them. It sometimes occurs that the lead vein is propagated upwards into the shale. This was the case at the Moothall Mine, Matlock, the Gang Mine, Cromford Moor, the Gregory Mine, Ashover, the Wakebridge, Crich, and the mines of Eyam and Castleton.

This fact would intimate to us that the richness of the mines depended much on the intensity of the electrical actions which took place with great force along this zigzag line of upheavement, or axis of disturbance, throughout the High and Low Peak of Derbyshire. Whether the lead veins of Yorkshire and elsewhere are in these respects similar, the writer has not been able to ascertain. The lead mines of West Yorkshire are still very productive.

A good deal of calamine (carbonate of zinc) was once obtained in Derbyshire, but since the introduction of the foreign spelter,* which is

* *This is smelted* with a given quantity of copper ore *to form brass, and* used extensively for making bronze *ornaments, &c. in* Birmingham.

obtained at a cheaper rate, it has quite declined. But the barytes, (Barium,) a sulphate of barytes, which is found with the lead ore, and once cast aside as refuse, is worked very extensively. It is broken up, washed, ground, and bleached by the aid of sulphuric acid, reduced to a fine powder, and sold as the Dutch lead of commerce.

The SPRINGS of the limestone are few in number, and depend solely on the clay beds, which, when unbroken, stop the water as it filters through the limestone. But the limestone being so full of veins, vaults, and caverns, the rain which falls is soon swallowed up, or runs off. Hence, on the high limestone basin about Newhaven and Newbiggin, and on all the limestone hills, the people are almost entirely dependent on miers* for their supply of water, both for their cattle and domestic use. In most places, and especially in dry seasons, the water has to be brought from considerable distances. Those who live on the margin of the grit and shale are abundantly supplied by the springs issuing from the former bed. We shall have to speak of these in treating of the grit and shale measures.†

* The Mier is a circular hollow, formed about the lowest part of a field, with channels cut from the higher ground around it to convey the water into it. The bottom of this hollow is carefully puddled with clay to retain the water; over this is placed a thick coat of gravel, and then it is pitched with stone to prevent the cattle injuring it.

† The importance of a good spring of water is strikingly seen in Numbers, xxi. 16, 17, 18—"The well of BEER. Then *Israel sang this* song: Spring up, O well, sing ye *unto it.*" *It is still* common in the East, and even in our

The fertility of the Peak is at present very great, solely owing to a better method of farming introduced by the all-pervading influence of the Agricultural Society, and the spirited efforts of some of the great landed proprietors. The Duke of Devonshire has done much to set an example, and so have other proprietors. We well remember passing through the Peak in 1811 and 1812, when little more could be seen but black oats, and bad coarse hay. But now, by improved culture, the best hay and the finest crops of corn are produced off the limestone.

The soil in the Peak differs materially. That on the limestone is very light, not very deep, and of a nut-brown colour. The grass is fine, bright, and sweet, forming excellent pastures. That on the limestone shale is stiff and sedgy land, requiring peculiar treatment and draining, when it becomes highly productive. The gritstone over its whole extent is remarkable for its heathy moorlands, (the purple heath, Erica cinerea, vulgaris, &c.) its hill sides are usually strewed with blocks of grit, some of immense size, therefore it is difficult to clear them; still it is done to a great extent, the broken grit being made into

own country, annually to perform some religious ceremony, and rejoice over the springs of water. At Buxton, Tissington, and Wirksworth, the wells, or springs, are dressed with flowers, and part of the Church Service is performed at them, accompanied with songs of praise to God. Such days are kept as holidays, and thousands *congregate from* great distances to join in the ceremony. *Every limestone* country is alike in regard to springs. *See I Kings,* xvii. 7, and elsewhere.

the boundary walls, (Derbyshire *hedges*, as they have been facetiously called,) and often, when necessary, piled into heaps, so that everywhere the busy hand of man is seen, and the arable field, or green sward, is gradually creeping up the hill and narrowing the boundary of the beautiful heath year by year.

STALACTITES are common in the limestone veins and caverns. This arises from the water containing a portion of lime held in solution by carbonic acid gas, which evaporates by exposure to the atmosphere, and the lime is deposited on the roof, sides, or floor of the cavern. If it drops from the roof, a pendant stalactite is the result; if from the sides, it is also a stalactite, and then often forms ripple-marks, owing to the inequalities of the rock. But that formed on the floor is called a stalagmite.

The hot springs deposit tufa very rapidly on the surface, and encrust whatever comes in their way. Hence the petrifying springs of Matlock, &c. which are calcareous, but the incrustations of the Gezhers of Iceland are siliceous. Beds twenty feet thick of Tufa, as it is called, are found at Matlock.*

The limestone is a bad building-stone, and used only in the Low Peak for filling up, except for outhouses, farm-steadings, mining coes, &c.; but in the High Peak, where brick clay is not to be found, and the gritstone is distant, it is used generally, except for the sills, sidings, and tops of

* The hot springs of Matlock and Buxton never vary in *volume, showing* that their source is deep, and *therefore unaffected by* what falls from the atmosphere.

the doors and windows, which are always of gritstone.

FOSSILS OF THE LIMESTONE.

Amongst the most numerous class of fossils in the carbonifirous limestone, is the Producta. It is, in fact, the *ruling* fossil, being found in the highest as well as in the lowest beds of these measures. The Producta gigantea occurs very large in the upper chert beds—one I measured being upwards of 8 inches in length, by 5 wide: but they gradually diminish in size as we descend in the measures. The largest under the first toadstone (294 feet deep,) is not more than 3 inches by 2, and the majority, especially of the Terebratula and Spirifer, do not exceed an inch either way. Below the second toadstone they are still less, and in some cases are found exceedingly minute. The Orthoceratite is found chiefly in the marble bed, with encrinital stems, though not confined to it. The bed of one yard below the marble bed is full of Terebratula; Spirifer, Orthoceratites, (sparingly). The Euomphalus, Goniatites, and Bellerophons, are chiefly obtained from about the middle of the second limestone, and are found of a much smaller size in the deep ferruginous limestone of Cauldron Low, in Staffordshire. Asaphus Trilobites, with Goniatites, are found in the Black Marble of Ashford, and they abound in the Rotten Stone (the *perished* black marble) of that neighbourhood; also Macrochilus, &c.

Producta gigantea, antiquata, scabriculas, *punctata*, Martini, &c.

Terebratula pleurodon, sulcata, porrecta, &c.
Spirifer glabra, cuspidata, trigonalis, &c.
Goniatites sphericus, Listeri, striatus and evolutus.
Bellerophon cornu-arietis, tangentialis and costatus.
Euomphalus pentagonalis, pentagulatus, &c.
Orthoceras laterale, cinctum, undatum, &c.

Besides these, we have the Conocardium minax, Inoceramus vetustus, Melania constricta, Pleurotomaria flammigera, Natica plicistria, and Turritella, Macrochilus, Patella, Isocardia, Nucula, and Pecten. Of Crinoideans we have Cyathocrinus planus, Antinocrinus triacontadactylus, Platycrinus lævis, and Trilobites in black marble and Rotton Stone.

CORALS.—Syringopora ramulosa, Cyathophyllum basaltiforme, turbinatum, dianthus, cæspitosum, Millepora rhombifera, and Retepora laxa. A variety of Astrea also occurs in the limestone, with remains of fishes.

LIMESTONE SHALE, OR SHIVER BED.

Having dwelt so fully on the limestone, we must be brief over this. It is a remarkable measure, containing very few, if any, fossils, except in its contact with the black limestone, and then it consists more of lime than alumina. The bottom bed, about a yard thick, is full of small Producta. In the fine black marble associated with this, we find Trilobites, Lingulæ, &c.; but throughout the higher beds nothing is found but here and there masses, or large flat boulders of *ironstone, from* two to three feet over, and multi-

tudes of small, round, and oval black balls, from the size of a pea to a bird's egg, very hard and siliceous, supposed to be seeds, or fruit; but nothing, as yet, is known respecting their origin. In the Willersley Tunnel, near Matlock, where the shale has been exposed and weathered, you might gather them by handfuls.

It is a very uncertain measure in its thickness, being readily denuded, or washed off, when exposed. In a mine sunk in a field near Matlock town, it is not more than thirty feet to the limestone; but in the Bullistree mine, near Cromford Bridge, it is twenty-five yards, or seventy-five feet; and within half a mile on the railway summit tunnel shaft, it has been sunk through to the depth of 160 feet, and not cut. But no doubt this is owing to a great fault in the limestone which occurs there, the shale having slidden down and filled up the fault. The tunnel is half a mile long, with only about twenty feet of limestone seen at each end. Where the whole amount of the gritstone is on, or above it, it seldom exceeds fifty feet. I mean the true limestone shale. This is in the Low Peak. But it becomes a very different affair when we move northward into the High Peak, about Castleton, &c. already alluded to, (page 47,) where the gritstone thins out, and is replaced with a fine sandstone, about a yard thick, alternating with a shale bed about six feet thick, containing occasionally a bed of bind, a hard, ferruginous, laminated clay, about a foot thick. Both this and the shale beds are readily weathered and destroyed when exposed; hence the steady and continued de-

struction of Mam Tor, or the Shivering Mountain, (Castleton), and other exposed points where such measures occur. Thus the sandstone bed becomes undermined, and when overbalanced, it topples down, bringing tons of shale with it. Hence, in cutting through such measures for roads, railway cuttings, &c. care should be taken to pare off the sides at a considerable angle, and to drain them also, and wall (face) them up with stone, if it can be done. The TOADSTONES require the same treatment, for though so hard at first, they weather fast too, though not so quickly as the shale.

This shale is finely laminated, of a black colour, and highly bituminous. The SPRINGS that issue from it are generally, if not always, chalybeate, which may be easily detected by the oxyde of iron (yellow ochre) which they deposit. The water is useful as a tonic, and is used for that purpose at Buxton and elsewhere. The thickness of these combined measures, viz. shale, grit, and bind, in Mam Tor, &c. is from 900 to 1,300 feet.

The limestone shale of Yorkshire presents the same variations of character and thickness; and so, wherever it exists, in England or on the Continent, in describing one part, we describe the whole. Petroleum (mineral tar) and naptha are found in the shale.*

* On all the road-sides, along the margin of the grit and shale, stone troughs are placed, to receive the water from the springs, for the benefit of the traffic on the road; and in a hilly country like Derbyshire, and parts of Yorkshire and Lancashire, it is no slight benefit to the *passer by*, especially in hot and sultry weather.

MILLSTONE GRIT.

The grit is decidedly one of the most important formations in England, both for its extent and utility. The whole range is called the Penine Chain—by the Romans, the Penine Alps.* By some it is called the "Back-bone" of England, from its great extent, breadth, and height. Cross Fell, in Northumberland, is the highest summit, being 2,001 feet above the sea. Kinder Scout, in Derbyshire, is very nearly 2,000; and Axe Edge, near Buxton, about 1,900. It forms a broad, magnificent ridge from Barrel Edge, south of Matlock, to the borders of Scotland, joining the Cheviot Hills in the north. In its whole length it has only two breaks; the valley of the Derwent in the south, and the valley of Todmorden in West Yorkshire. It may be said to be the great water-shed of this part of England. From it, on both sides, flow numerous streams and rivers. On the east, the Ouse, with its numberless tributaries, falls into the Humber. The noble Trent, on its southern border, with its tributaries, adds its waters to the same estuary. On the west we have the Mersey and the Ribble, with their numerous feeders, proceeding from it. When we come, therefore, to consider the utility and great importance of these estuaries and rivers in a commercial point of view, besides the vast supply of water the chain affords, throughout its course, to an immense and busy population in the towns and villages that

* *This is probably* taken from the old British term, *Pen, meaning head,* or summit.

occupy its sides, and nestle in its dales and valleys, or on its plains stretching outwards east and west from its base—with the multitude of corn, saw, bleaching mills and factories that press its waters into their service, we shall not be thought to have over-rated the value of this great Penine Chain.

The millstone grit may be divided into *four* sections, viz.:—

1. Argillaceous grit.
2. Red, or ferruginous grit, and conglomerate.
3. Variegated grit.
4. Fine-grained grit, generally of a drab colour.

The first consists of a great number of thin, flaggy beds, and generally sufficiently thin to form roofing slates, which are extensively used in Derbyshire and Yorkshire for roofing farmsteadings and buildings of minor importance. This is often highly micaceous. Thickness, from twenty to thirty feet.

The second is remarkably varied in its character. In some parts of the range a deep, bright red prevails; in others, a drab-colour mixed with bands of yellow, as in parts of Derbyshire, near Matlock, where it is quarried for building-stones, stone troughs, and millstones;* but this is elsewhere replaced by a conglomerate, or a coarse pebbly grit, as about Alton Towers in Staffordshire, Froggatt Edge on the Derwent, (Derby-

* The quarries at Hotstandwell Bridge (Whatstandwell) have been worked for these purposes for upwards of a century, and are of great extent. It is called millstone *grit, because* millstones are quarried out of it.

shire,) in parts of Wharf Dale, (Yorkshire,) and elsewhere.

The third is the beautiful variegated sandstone, of which Chatsworth House is built. This occurs in great force in the neighbourhood of that celebrated mansion. The most important quarries are those of Bakewell Edge and Beely Moor.

The lowest bed, or fourth division, is of considerable thickness, being from 100 to 200 feet. This is of a quiet drab colour, of various shades, sometimes coarse-grained. This, if not too coarse, is also used for millstones. But for durability and colour, it may be said to be one of the finest building-stones in the world. Blocks of immense size are obtained out of it, some of fifteen tons weight, or more, have been sent to form the magnificent pillars in front of the old station at Birmingham; and more recently, it has been used in enormous blocks for the erection of St. George's Hall, Liverpool. The noble elevation of the front of that building, pillars, frieze, architrave, &c. is all formed of this stone; it was taken out of the celebrated Darley Dale quarry, now so well known.* The ridge, throughout its wide extent, produces good building-stone.

The grit is evidently the result of the decomposition and abrasion of the granites, for it may be said to contain the same ingredients in an altered form; viz. mica, quartz, and feldspar. The slaty *contains* the most mica, (micaceous sandstone;)

* *This lies between* Matlock and Bakewell, near to *Rowsley.*

the next, when pebbly, the most quartz, (granular grit;) the other two contain about equal parts of the quartz and feldspar, with less mica. The colour is due to the presence of oxyde of iron. In the deep red, the whole is thoroughly coloured with it, but in the variegated, it has been only occasionally deposited, and with more or less intensity in the course of the formation of the sandstone; hence it follows the flexures of each bed with its ripple-marks, and forms a fine feature in some of its building stones, especially in those of Chatsworth.*

We have already spoken of its springs and its agricultural character, (pages 63, 64,) and need only add, that it forms all the high moorlands so well known in the north of England. Its lofty summits are everywhere covered with heath and mosses, and there are mighty blocks of stone in some places, with myriads of smaller ones; also bogs and pools of water; its hill-sides and glens are strewed with stony blocks covered with moss and lichens, which, when decayed, and especially in winter, give to it a stern and forbidding aspect. But there is something grand and imposing in its dark and frowning rocks that here and there overhang the valleys, that is not equalled, perhaps, in other formations. Stonnis, or the Black Rocks above Cromford, Corber and Froggat Edge, on the Derwent, also on the Goyte, and in Glossop, Wensley and Wharf Dales, (Yorkshire,)

* The noble gateways and lodges at the entrance of Chatsworth are beautiful specimens of the "folds" in this stone. *It appears in some of the masonry very much like drapery.*

are all striking exhibitions of the character of these rocks. Its valleys, too, are many of them fine, even beautiful. Parts of the valley of the Derwent, in Derbyshire, and that of Todmorden, in Yorkshire, are fine examples.

To this formation also belong some beautiful waterfalls. Hardrow Force in Wensley Dale, Ashgill Force in Aldstone Moor, Lumsdale in Derbyshire, &c. are rather imposing, especially after heavy falls of rain, when the streams are swollen into torrents; then they tear along their rugged channels, and fling themselves into the abysses below with terrific force and fearful uproar.

The ROCKING STONES must not be omitted. These occur in several parts of the range, but none that we know of are equal to the Router Rocks at Birchover, and the Durwood Tors on Hartle Moor, near Youlgrave, Derbyshire. Masses of rock of many tons weight can be moved with the greatest ease. This arises from the fact of the gritstone being liable to weather, or wash away, in some of its beds; hence the elevated and exposed rocks are worn away where the softer beds occur in them, and leaving the top part of the rock in a trough, or hollow basin, somewhat like a cup and ball. This forms the loose joint, and every storm that sets in keeps it in motion.

The gritstone contains very few organic remains, and they are chiefly Calamites and a few *Ferns.* Thin beds of bad coal occur in it; there *is one in Northumberland with an area of 50,000 acres,* and another in the West Riding

of Yorkshire and Lancashire of 650,000 acres. A very small area occurs in Comb Moss, near Buxton, where the inhabitants use it in their sitting-rooms, (not for cooking,) but it burns with difficulty, and makes but a cheerless fire.

The millstone grit is very feebly developed in the south of England, near Bristol, and likewise in Scotland. On the continent it is almost entirely absent.

A variety of oxyde of manganese, in a loose, friable state, occurs in the top measures of the grit. It has the appearance of having been exposed to great heat; but where this metal is found in the limestone, it is crystalline. The former variety is used as the Umber of commerce. Sometimes very thin veins of lead are found in the fissures of the Grit. The author possesses a piece of lead obtained out of the gritstone quarry of Milford Bridge, near Belper.

COAL-MEASURES.

The coal-measures are, beyond comparison, the most important of all the rock formations to man in general, and especially so to GREAT BRITAIN; for we know that, under Divine Providence, they have been one of the chief causes of raising her to a higher degree of prosperity and glory than has been enjoyed by any of the past or present nations of the earth. We, therefore, approach the description of them with some hesitation, lest we should fail in giving such an account of them as will be sufficiently clear and satisfactory to the young student. And this is *increased* by the fact, that the circumstances under

which the coal-measures were formed, are still a subject of doubt with the most enlightened geologists of the day; there is nothing doubtful as to the fact of the vegetable origin of coal; that is evident by every step we take in its investigation; but whether the multiplied and ever recurring beds of coal of varying thicknesses, from half-an-inch to forty feet, with alternating beds of shale, sandstone, and limestone, occurring between—whether all this was effected by the drift system, or by successive depressions and elevations of the land on which the magnificent flora of the coal-beds grew, is a problem still to be solved. The myriads of impressions of ancient ferns, reeds, conifers, horsetails, cycads, &c. some of them gigantic trees,* (from five feet long to seventy, and from one to fifteen feet in diameter,) found in the coal measures, leave no question as to the material of which the coal has been formed.

Professor Goppert, after examining the fossil vegetables of the coal-fields of Germany, has detected in beds of pure coal remains of plants of every family hitherto known to occur fossil in the coal. "Many seams," he remarks, "are rich in Sigillaria, Lepidodendron, and Stigmaria; the latter in such abundance, as to appear to form

* Part of the trunk of a large tree, about sixty feet long, denuded of its branches, reclines at about an angle of 30 degrees in the sandstone of Craigleith quarry, near Edinburgh; and Mr. Hugh Miller mentions four more huge trunks, in similar positions, exposed in other quarries near that city. Mr. Hawkshaw also discovered parts of erect fossil trees, broken off a few feet above the [illegible] on the Manchester and Bolton Railway.

the bulk of the coal. In some places almost all the plants are calamites, in others ferns." *

We shall now endeavour to give an account of what a coal-field is. In character and aspect it differs materially from all other parts of the country. Instead of the fine swelling eminences and low flat plains of the New red sandstone, generally in its immediate neighbourhood, it presents a multitude of low, ridgy, angular hills, of no great length, with ravines, or little valleys between, as if the whole district had been lifted and broken up into numberless sections, and without order.† This peculiarity is the effect of the many faults which occur in the coal-fields; a circumstance, as we shall presently see, that happily enables the miner to get the deep coal. Another fact cannot fail to be observed, and that is, the coal clay, of a particular drab colour, is seen every now and then peering out beneath the hedge-rows, and on the roadside and lanes, all over the district. This is what is often termed the fire-clay, and is a sure indication of the presence of coal, even if the coal basset nowhere appears in sight.‡ These under clays are co-extensive with every layer of coal, and "are regarded by the colliers in South Wales as an essential accompaniment of each of the 100

* El. 4th ed. p. 316, quoted by Lyell.

† This is usually the case, except where the coal-basin is tilted, or elevated on one side by the steep slopes of the grits, or other rocks on which it rests.

‡ This is called fire-clay, because the bricks made of it resist the action of intense heat better than bricks made of other clays. It is also used extensively for earthenware, &c. hence also called Potters'-clay.

seams of coal met with in their field." They form the floor on which the coal rests, and in which the roots and branches of Stigmaria are abundantly distributed. This very abundant fossil is now discovered to be the root of Sigillaria, by finding them connected together as such. Another character is, that all the coal-fields are basin-shaped, as if the coal had been deposited in lakes, estuaries, or hollows of the sea at the mouths of rivers, which was probably the case. For instance, taking the Derbyshire and Yorkshire coal-fields into view, by ascending some of the lofty points of the grit on one side, or of the magnesian limetone on the other, we shall find this to be the case. Ascend, for instance, the lofty position of Bolsover Castle, near Chesterfield, which commands both fields; it will appear, as far as the eye can reach both ways, that these fields lie in a trough, or broad valley, between the high ridges of the gritstone to the westward, on which they rest, and the lower eminences to the east of the magnesian limestone, under which they dip. The extent of both fields, from four miles north of Derby, to the neighbourhood of Leeds, is about sixty miles; the greatest breadth (in the Yorkshire part) being about twenty-two. Take any one of the coal-fields—Stafford, south or north, Salop, Somerset, or South Wales, all, as a whole, assume this form, yet their general dip is governed by the rock on which they rest. This dip in England is eastward.

As we have given a view of the external *aspect of a coal*-field, let us descend beneath the

surface, and see of what materials it is composed. We shall first take the Newcastle coal-field, as given by one of the managers, (Mr. Westgarth Forster,) and quoted by the late Professor Phillips in the Cabinet Cyclopædia, (Geology, vol. i. p. 157.) Here the first overlying rock, as in the Whitehaven coal-field, is the magnesian limestone. He gives us first in his section, 74 feet of brown sandstone, as he terms it, or arenaceous magnesian limestone,* and then a thin coal of six inches. He then gives 360 feet of various beds of shale, sandstone, bind, clunch, (indurated ferruginous clay,) in many beds alternating with five beds of thin, unworkable coal, 6, 8, and 12 inches thick each. Then we come to the two-yard coal. In the next 651 feet, interstratified with shales, &c. we have no less than two of the two-yard coal, five of one yard, with twelve beds of thin coal, varying from 3 inches to 18 inches thick; the lowest bed is one yard two inches thick, and the one thirty feet above, is a two-

* Called by the miners brown paste, or grindstone sill. We may observe here that the prevailing rock is shale, (provincially called *plate*,) with various beds of sandstone differing in hardness and texture, and according to these distinguished, as the freestones, hazles, whetstones, grindstones, and millstones. A singular circumstance was pointed out to me by Mr. Bourne of the Denby Potteries when examining the out-crop of the two-feet coal under which he obtains his fire clay; namely, that the strines, or twigs, or small branches of the wood, were invariably inserted in the clay, but all the ferns (leaves) were found in the shale above the coal-bed. No doubt they were broken off, and floated upwards to the top, *and settled there.*

yard coal. The thick beds are from 30 to 71 feet apart from each other, the thinner beds being intermediate, altogether giving a thickness of 1085 feet. This we have given more fully, to show the general arrangement of the Newcastle-on-Tyne coal-field, and also to show the complications existing in the coal-fields.

In the Derbyshire coal-field, at Clay Cross, Codnor Park, &c. the mines are not so deep as those we have described, but abound with clay ironstone, which scarcely exists in the Newcastle field; hence the increased value of these fields from the manufacture of iron, which is effected at these places to a great extent; and, in fact, this constitutes the great difference between the the coal-fields of the continent, where, iron being generally absent, the coal is only useful as a fuel; but at Codnor Park, Clay Cross, and Butterley, near Ripley, blast-furnaces are erected, and a great weight of pig-iron is manufactured annually, and converted into bar and sheet-iron, with castings of all kinds. On sinking to the deep coal at Clay Cross, (600 feet,) with the usual beds of shale, bind, and clunch, thick beds of clay ironstone are found in bands and nodules. The Mussel Band (a fresh-water shell) is very productive of ore. But near Alfreton, and at Morley Park, the iron ore (a carbonate) occurs on the surface, arranged in circular basins closely joined together, so that when one is emptied of its ore, the refuse of the next one is thrown into *it, thus* partly filling up and making good the *ground as they* proceed. This is by far the *cheapest mode of* getting this ore. The furnaces

and works at Butterley, Codnor Park, and Clay Cross, are worth a visit.

In South Stafford, about Dudley and Bilston, the beds of coal are of great thickness. There they have what is called the ten-yard coal, besides seams of less thickness that are workable. Here the coal measures rest immediately on the Silurian rocks, without the intervention of the Old red sandstone, gritstone, or mountain limestone. But here the grit, under the term of coal grit, with coarse limestones, including shales, clunch, &c. in many beds are interstratified with the coal, so as fully to represent the whole carboniferous system. At Bradley Colliery, near Bilston, the eight-yard coal was reached at the depth of 150 feet, and the ten-yard, in a mine in the neighbourhood, at the depth of 495 feet;* and here, too, is found an abundance of ironstone in connexion with the coal, which is the prevailing feature in the coal-fields of England. From Walsal to Wednesbury, Bilston, Dudley, and Wolverhampton, (north of Birmingham,) the whole country appears covered with coal-mines, furnaces, and glass-houses, which have contributed not a little to the vast enlargement and prosperity of Birmingham, the toy-shop of the world.

The late Lord Dudley cut an underground

* The specimen shown in the Crystal Palace of this coal, 13 tons, (1851) came from the Tipton Pit, belonging to Hains and Sons, of Denby Hall. But the fine column showing a vertical section of the working seams, (40 feet high,) came from West Bromwich, sent by *Messrs. Bagnall* and Jesson.

stone. A valuable deposit of coal and black band iron-stone, extends from Glasgow to Carluke, a distance of twenty miles, from whence the celebrated Carron iron-works are supplied. These works are on a most extensive scale, and almost every kind of iron work is done there. When we visited them, some years ago, they had large orders for cannon from the government of the day. The process of casting and boring of which we had the opportunity of seeing.

In the coal-fields fresh-water formations, to a small extent, frequently prevail. "In that of Edinburgh, at Burdiehouse, fossil fishes, mollusca and cypris, very similar to those in Shropshire and Staffordshire, have been found by Dr. Hibbert. In the coal-fields also of Yorkshire, there are fresh-water strata, some of which contain shells referred to the genus Unio; but in the midst of the series there is one thin, but very widely spread stratum, abounding in fishes and marine shells, such as Goniatites Listeri, Orthoceras, and Avicula papyracea."

There are many other coal-fields that might be noticed in Great Britain, Ireland, and on the continent of Europe, but want of space prevents us saying more on the subject; besides, we hope enough has been advanced to show clearly the character and value of the coal-beds. We shall point out some of the fossil flora, before giving a brief sketch of the American coal-fields.

As already stated, (page 77,) ferns and cal*amites* seem to be by far the most numerous [illegible]*milies, so as* even to constitute a great part, at [illegible]*st, of the* German coal-fields. The ferns now

so dwarfish, were in the ancient world magnificent trees, and no less than 250 varieties have already been obtained from the coal strata. This is, observes Sir Charles Lyell, a singular result, because the whole of Europe only affords at present no more than 50 indigenous species.* Amongst the ferns most commonly found are Pecopteris lonchitiça, aquilina, and affinis. Sphenopteris, crenata, and Hœnighausi, Caulopteris Phillipsii, and primæva. Also a variety of the genera Neuropteris and Odontopteris occur, but in less numbers. Sigillaria lævigata, pachyderma, and organum, are the most common of this class. Stigmaria ficoides, and other species, abound in the coal-beds. Lepidodendron Sternbergii occurs, and a peculiar oval-formed species, the Lepidostrobus ornatus, which is considered by M. Brongniart to be the fruit of Lepidodendron. The calamites are also abundant. Among the most common are Calamites cannæformis, and suckowii; also Asterophyllites foliosa, &c. Club-mosses, (lycopodiaceæ,) and horse-tails (equisetaceæ,) abound in the coal-beds, as well as pines (coniferæ,) in great quantities.

Sauroid fishes have been discovered at Burdiehouse, near Edinburgh, one called the Holoptychius, and the other the Megalichthys, (megale great, ichthys fish.) And one reptile in the coal formation of the midland counties, the Archegosaurus, two of the vertebra of which the author obtained from Codnor Park colliery.

The North American coal-fields are of immense extent, being no less than 720 miles in length, by

* Lyell, p. 311.

about 180 miles in breadth, consisting of two fields, divided simply by the high peaks of the Alleghanies. The one is the Illinois coal-field, which lies to the west, and the Apalachian to the east of the mountains. On a moderate calculation, says Sir C. Lyell, their superficial area amounts to 63,000 square miles. In the region near Pottsville, where the thickness of the coal-measures is greatest, there are thirteen seams of anthracitic-coal, several of them more than two yards thick. Some of the lowest of these alternate with beds of white grit and conglomerate of coarser grain, different to any that occur elsewhere, associated with pure coal. These coal-fields are intersected by three great navigable rivers, the Monongahela, the Alleghany, and the Ohio, all of which lay open on their banks the seams of coal. Consequently the boats are brought to the openings of the pits, and the waggons are run out on rails, and emptied into the boats with little trouble. These coal-fields lying nearly horizontal, allow of their being worked on a level horizontally, thus facilitating the operation of removal, a matter of great consequence in these fields, and not occurring elsewhere; in consequence of this, the mines can be sufficiently drained of their water at little expense. Sir C. Lyell has given a sketch in his elements, (1852,) looking down the Monongahela, to Brownsville, (Pennsylvania U. S.) which gives a good view of the main seam of *bituminous* coal, ten feet thick, commonly called *the Pittsburg* seam, breaking out in the *steep cliff at* the water's edge. "These coal-

fields," adds Sir C. Lyell, "are capable of supplying for ages, to the inhabitants of a densely peopled region, an inexaustible supply of fuel. Here almost every proprietor can open a coal-pit on his own land, and the stratification being very regular, he may calculate with precision the depth at which coal may be won."

No real coal has been found in South America, or in Africa. There are some good coal-fields in Canada, and Nova Scotia; in Spain, France, Belgium, and Germany; also in Russia, Turkey, in Asia, India, (Cutch) China, in the Island of Borneo, and Australia,* but our limits forbid our doing more than merely to name them. And the same reason prevents us from giving a description of the mode of working a coal-mine. We can but remark that very many seams of coal cannot be worked, however good, because they are so thin. One is now in work near Chesterfield only twenty-two inches thick, but the expense and labour are great, from the fact that a portion of the roof requires to be removed in order that

* Coal thus existing in all climates, even in Siberia and Greenland, show that at one period of time one uniform temperature existed over every region of the earth, for the coal flora is the same everywhere, being of a tropical character; but, as Sir Charles Lyell remarks, it does not indicate a climate resembling that now enjoyed in the equatorial zone. "A great predominance of ferns, and lycopodiums, only indicates warmth, moisture, equability of temperature, and freedom from frost, rather than intense heat." Some recent writers suppose that the climate of the coal period was warm, gloomy, and moist, in which carbonic acid gas prevailed in the atmosphere. *But this* is mere speculation.

the men and boys employed may have room to labour, and then the work has to be done in a stooping or kneeling posture, and often the workman lies prostrate. Little boys are employed to run the coal waggons on tiny rails to the bottom of the drawing shaft. But in a coal-mine where the five and six feet seams occur, they can have ponies, donkeys, and horses, with rails and quantities of waggons to do the work, and these animals remain below for years before they are again brought to the surface.*

The coal in some pits is worked out in galleries running at right-angles to each other across the field, leaving a wall of coal on each side to support the roof; but in others pillars of coal are left for this purpose, and when any part of the field is exhausted, even these are carefully removed by degrees where it can be done, and then the ground gradually subsides.

With regard to the formation of the coal-beds, the author would simply remark that both the drift method and the undulatory may have occurred at intervals. When we look at the position of the coal-beds in relation to that of the other strata, we find they lie midway between the highest rock and the lowest generally; but they sometimes rest on rocks, as the Old red sandstone and the Silurians, which rest immediately on metamorphic, or changed rocks. We

* The stables for these animals are very comfortable, and constructed near the upcast shaft, where a roaring fire is constantly kept up; this occasions a draught, and helps to consume the foul air, or fire-damp, in the mine, and prevent explosions.

may easily conceive, therefore, that these rocks, spread over a heated nucleus, would be frequently disturbed by undulatory actions in those earlier periods of time, and thus give rise to repeated depositions of coal, sand, silts, &c. On the other hand we have a splendid example of the drift system as exhibited at the mouth of the magnificent Mississippi, the longest river in the world, (4,000 miles, including the Missouri branch;) there, stretching into the Gulf of Mexico, is a sand-bank 500 miles long, 30 of which are now left dry, where myriads upon myriads of trees, and all kinds of vegetable matter are embedded in succession, with sand and silt between each layer of wood, and under great pressure in deep water, are being converted into lignite and coal.* See Lyell's principles for a full account of the drifts of the Mississippi and the Missouri.

Another supposed source of the coal-beds by the undulatory system, is from the vast accumulations of peat-bogs, which no doubt are at the present day very extensive and deep, and may have been one of the causes of the production of coal. But one thing is quite obvious, that by whatever method these may have been deposited, it was the purpose of Divine providence they

* Sir James Hall, by placing a piece of wood in water under great pressure, and passing a shock of electricity through it, charred it and converted it into a kind of coal. A hay-stack put together in too damp a state, and taking fire, furnishes a good idea of what takes place with vegetable matter *placed* at the bottom of the sea or in estuaries *under pressure* and the air excluded.

should exist for the multiplied and varied wants of mankind. Their utility, I may say their necessity, is self-evident. What could we do without iron? and this iron could not be produced in quantity unless we had coal as a fuel, and limestone as a flux, which is also found near by. Where would our Manchester have been with her machinery, and millions of spindles? and Sheffield and Birmingham with their hardwares, besides other towns without number in other countries? and then the Rail, too, with its vast stock of locomotives, &c.? And with our vastly increased population, where could we have found fuel for even our common purposes, besides the consumption by steam everywhere, by sea and on land? Our requirements are now so vast, that not less than 64,453,000 tons of coal are raised annually in this country alone, and we make in the same time about 10 million pounds worth of iron for our necessary purposes. Let us be thankful, then, that an all-wise God has stored up for us in past time such an ample and apparently inexhaustible supply of coal and iron for our good always.

With regard to the character of the coal from various fields, it may be stated that the Newcastle coal is a caking coal, and gives a good heat; but the pure Welch (South) anthracitic coal is considered the best for producing the most heat. There is also what is termed a steam-coal, (bituminous,) found also in Wales, which is highly esteemed. The cannel coal, which is *fine-grained and* compact, some of it hard enough *to be made into* ornaments, is considered the best

for the manufacture of gas. This is found abundantly in the West Yorkshire coal-fields, also in Derbyshire, in Scotland, and else-where.

Professor Bronn estimates the number of the extinct flora at 2,055, but the recent at not less than 69,403.

PERMIAN SYSTEM, OR NEWER PALEOZOIC.

This system once formed part of the Triassic, or new red sandstone system; but Sir R. Murchison, finding it so extensively developed in Russia, as to occupy the whole of the ancient kingdom of Permia, extending about 700 miles from north to south along the western or European flanks of the Ural chain, and for nearly 400 miles between those mountains and the river Volga, was induced to form it into a distinct system under the name of Permian. In Germany it is also largely developed, and in this country, from Nottingham to the mouth of the Tyne, it may be traced continuously. The system consists of the Lower new red sandstone, which rests on the coal, and its upper beds consist of the magnesian limestone and marls. The lower member (new red) is comprised of a few marly beds, with bands of shelly limestone, and inferior sandstones of various colours, but chiefly of a greenish dun colour. In some places, where this sandstone becomes compact and hard, it is used at times as a building-stone. This is called by the Germans *Rothe todte liegende*, red dead lyer, because it is destitute of copper ore, which is found in considerable quantities in the magnesian limestones above it in Germany.

In the upper members we have magnesian limestone and magnesian conglomerate, with thin beds of red marl, in which gypsum occurs.* On the east coast of Durham and Yorkshire, the magnesian limestone appears oolitic, concretionary, and botryoidal, some of the round balls being as small as a pea, (Blidworth Pearls,) and others as large as a cannon-ball, which give a remarkable appearance to the cliffs.

The magnesian limestone of Roach Abbey, near Bawtry, (Yorkshire,) is of a light cream colour, and a good building-stone; but that of Bolsover† and Mansfield is of a beautiful light brown, or salmon colour, with a semi-crystalline structure, and glimmering lustre. The New Houses of Parliament are built of this stone, and York Cathedral and the city walls are built of the former.

When it is close grained it is called Dolomite, and in this state it is sometimes formed into cisterns, stone troughs, and other purposes. Its flora and fauna are nearly similar to that of the carboniferous series. The fossils are the Producta aculeata and calva, Spirifer undulatus, Axinus Schlotheimi and truncatus, Myalina acuminata, &c. Corals—Fenestella retiformis, Retepora flustracea, and a Gorgonia. Several species of Sauroid fishes are also found, as the

* These concretionary masses are sometimes grouped together like chain-shot. A variety found at Sunderland is sometimes quite flexible.

† *In this place the* beds are separated by pipe-clay, *which is used in the* arts, and pipes are made of it exclusively.

Palæoniscus comtus, elegans and glaphyrus; also Cælacanthus, Pygopterus, and Acrolepis Sedgwickii. Also teeth of the reptiles Thecodontosaurus and Palæosaurus platyodon. The plants are—Calamites gigas, Sphenopteris erosa and lobata, also species of Neuropteris, Pecopteris, Asterophyllites, Annularia, and Lepidodendron.

It is burnt as lime for manure, but its contained magnesia deteriorates its quality. Some of it has the property of setting under water. It forms a poorish thin red soil, which, however, is much improved by lime made from the carboniferous limestone. The cliffs and deep dales about Pleasley, Bolsover, and in the neighbourhood of Knaresborough, are very picturesque. It is cavernous in places. Wokey Hole, in Somersetshire, is in this limestone. In Derbyshire it does not exceed 300 feet in thickness.

GENERAL REMARKS.

The three groups we have been considering are distinguished by some leading fossils peculiar to each. The Silurian is specially marked by the Trilobites (oldest crustaceans,) which abound in it, one species only being continued into the black marble of the carboniferous group. This marble at Ashford, (Derbyshire,) perishes, and then is converted into rotten stone, (the rotten stone of commerce,) in which these trilobites are abundantly found, but at this point they die out. The chain coral is peculiar to the Silurian alone.

The Old red sandstone is characterized by its Crustacean fishes, pterichthys, &c. found, as yet, *nowhere else*; and the Carboniferous limestone

by its multitudes of Productæ, some of very large size, and others exceedingly minute. Besides its thick bed (12 feet) of grey marble, full of the broken stems of the encrinite. The Producta is also found in the magnesian limestone, where it ceases.

These are peculiar features not to be mistaken by the close observer in geological studies.

CHAPTER V.

ON THE ROCKS AND FOSSILS OF THE SECONDARY EPOCH.*

UPPER NEW RED SANDSTONE, OR TRIASSIC.

THE deposits belonging to the first of these systems are so named from the tripartite division of them observed on the continent of Europe, where a calcareous rock of some importance, (the Muschelkalk,) intervenes between two arenaceous rocks, called respectively Keuper and Bunter-sandstone.† In England, the absence of the limestone leaves no means of distinguishing between the two sands, which are only

* Dr. Mantell calls this period the "Age of Reptiles." "As we ascend," he states, (Medals, p. 687,) "in the secondary formations, we are suddenly surrounded by innumerable marine and terrestrial Reptiles, belonging to species and genera of which no living representatives are known. Throughout the Liassic, Oolitic, Wealden, and Cretaceous epochs, the class of Reptiles was at its fullest development."

† *In France the* keuper is called Marnes irisées, (variegated marls,) *the* Muschelkalk, or Calcaire coquillier,

spoken of as distinct, owing to the presence of some doubtful fossils, and a more marly character, combined with beds of gypsum and rock salt in the upper part. The British series is designated Upper new red sandstone. (*Ansted*, page 393.)

This is a very extensive deposit, stretching with very little interruption from the northern bank of the Tees at Durham, to the southern coast of Devonshire; but it attains its greatest development in the Midland Counties. Here, it expands into a vast tract of nearly level country, varied here and there with low eminences and finely-rounded hills of slight elevation. The valley of the Trent, Cheshire, the southern part of Lancashire, and northern part of Shropshire, watered by the Dee, the Mersey, and the Weaver, exhibit these features to perfection. In the three counties named the uppermost beds of the new red sandstone are chiefly developed, in which we find the great salt-works at Nantwich. The whole of this district abounds with brine springs, which is continued southward to Droitwich, in Worcestershire. In Cheshire occur extensive masses of rock-salt in a solid state, their total thickness amounting to not less than 60 feet. These alternate with beds of gypsum; with numerous bands of indurated clay of blue, red, or brown colour, and with sandstones frequently marly and of a red colour. At Tutbury, in South

and the Bunter Grès Bigarré. The word poikilitic is sometimes used to designate this system, which is derived from the Greek word ποικιλος, poikilos, variegated, from the variegated colours these rocks generally assume.

Staffordshire, and at Aston and Chelleston, near Derby, the gypsum, or Derbyshire alabaster, is extensively quarried and calcined into plaster of Paris for casts, moulds, flooring, &c; but the purest varieties are sold to the manufacturers of Derby and elsewhere to be converted into ornaments of all kinds. The splendid pillars in the great hall of Lord Scarsdale's seat at Kedleston, near Derby, are made of this stone, and also the casing of the stairs in the great hall, and the carved facings of the entrance doors to the state-rooms at Chatsworth.* Another exceedingly beautiful variety is found in the same marly formation at Red-Hill, near Nottingham. This is a fibrous gypsum of the purest white, which is turned into beads for necklaces, bracelets, &c. millions of which have been sold on the continent of Europe, besides great quantities in this country.

The lowest beds of the Upper new red sandstone, are chiefly found in the middle of England, and consist of soft sandstones of a whitish, and sometimes, perhaps more frequently, of a reddish colour.† In some places, (as in Staffordshire,

* A magnificent vase made of this stone (the variegated) with carved handles, about 8 feet over, was manufactured at Hall's spar works, Derby, for the Economical Museum, Jermyn Street, London, and some fine things, also, for the British Museum. The moulds used to protect the china in the kilns are made of the burnt plaster.

† Nottingham Castle and Town stand on this formation, in which have been excavated not only deep, dry *cellars* for most of the houses, but considerable excavations were once inhabited by the lower orders. There is a long descending gallery with occasional openings from the castle to the street below.

about Alton Towers, &c.) these are surmounted by conglomerates composed of rounded pebbles of quartz rock, and other fragments chiefly of silurian rocks and old red sandstone. This formation is continued into Gloucestershire, (Valley of the Severn,) and part of Somerset; and, as we have already observed, to the southern coast of Devon. This formation is extensively developed in the Valley of Connecticut, and other parts of North America.

This group on the continent, in Germany particularly, consists of numerous series of mottled marls of red, greenish grey, or blue colour, which pass into green marls, black, slaty clays, and fine-grained sandstones. Throughout the series, rock salt and gypsum are abundant; but the organic remains of animals are extremely rare. These are the keuper marls, or marnes irisées. Then succeeds the muschelkalk, which is a compact greyish or greenish-coloured limestone, and commonly contains, in great abundance, the remains of shells and fragments of radiated animals and fishes, which frequently give to this rock a splendid appearance from its shining iridescent colours.* Sometimes the muschelkalk is a bituminous rock, and emits a disagreeable odour when struck with the hammer. (*Ansted*, p. 396.)

The Grès Bigarré, or Bunter sandstein, is a fine-grained solid sandstone, sometimes white, but more frequently of a red-blue, or greenish tint. Mica is very frequently distributed through

* *Snuff-boxes, slabs,* and other ornaments are made of it.

the whole series, which gives it a glistening aspect and slaty structure. It is generally too soft for building purposes. The conglomerate, however, of the Bunter sandstein is sometimes converted into millstones; and at Runcorn, in Cheshire, and in part of Lancashire, the sandstone is sufficiently hard and compact to form a good building-stone: but all the upper members of this formation are totally unfit for that purpose; hence we find in various parts of its course, houses formed of wooden frame-work filled in with brick, or lath and plaster, such as once prevailed in the tertiary districts around London.* The chief fossils found in the series are the Ammonites (Ceratites) nodosus, minute bivalve crustacean, and Avicula socialis, a plant called Voltzia heterophylla, and fishes' teeth, (including Hybodus plicatilis, Saurichthys apicalis, Gyrolepis tenuistriatus,) and Encrinites moniliformis. But that which distinguishes this formation specially, are the multitudes of the foot-prints of Batrachians and gigantic birds. The foot-prints being in the form of a man's hand, the animal called the Labyrinthodon first acquired the name of Chirotherium, (cheir, a hand, and therion, a wild beast.) The head, the pelvis, and part of the scapula of this gigantic

*A remarkable instance of this is seen in the two finest churches of Coventry, with their tall and beautiful towers and spires; the stone of which they are built being so soft, soon decays, so that these fine towers have been obliged to be recased; the bells of the one to be taken down, and those of the other to be supported by strong framework of wood.

Toad (13 feet long,) were found near Warwick, the restored outline of which, by Professor Owen, is now in the Crystal Palace grounds.* Impressions also of the feet of a bird four times larger than the ostrich, but perhaps not larger than the Dinornis found in New Zealand, have been discovered. Thousands of smaller foot-prints of birds have also been seen in America. This formation is from 1,000 to 1,500 feet thick.

LIAS FORMATION.—This formation is, perhaps, one of the most remarkable of all the groups of rocks, from its contained organisms of shells, Belemnites, Ammonites, Saurian fish, and enormous Reptiles. The gryphæa incurva, (a kind of oyster,) is so abundant, that it has been called the gryphite limestone. The English provincial name of lias (flat layer) has been very generally given to it by geologists. The peculiar aspect which is most characteristic of the lias in England, France, and Germany, is an alternation of thin beds of blue or grey limestones, with a surface becoming light-brown when weathered, these beds being separated by dark-coloured, narrow argillaceous partings, so that the quarries of this rock at a distance assume a striped and riband-like appearance. This characteristic is well seen at Lyme Regis, Whitby, and Barrow-upon-Soar.† The upper lias, or alum shale, so well-known, is strikingly developed at Whitby, and on other parts of the Yorkshire coast. There

*The name Labyrinthodon was given from a section of its tooth exhibiting multitudinous foldings, not unlike those of the *human* brain.

†Conyb. and Phil. p. 261.

it consists of three distinct parts; the lower division including soft shales, extremely fossiliferous, are separated from the uppermost series, also composed of incoherent slaty beds, by an intermediate stratum of hard shale, about thirty feet thick, containing a quantity of the mineral called "jet," and also occasionally large fragments of the bituminised wood of coniferous trees. "It is in these upper shales of the lias, both on the coast of Yorkshire and at Lyme Regis, that there have been found the most remarkable of those fossil remains of extinct animals, for which the formation is so celebrated, the Plesiosaurus and Ichthyosaurus."

The middle bed of the lias is most strongly developed in the neighbourhood of Cheltenham, where the marl stone of Dumbleton Hill is crowded with the most interesting organic remains. This hill is made up of alternating layers of coloured clays and sands, some of which are often calcareous, and occasional beds of impure limestone; in which, sometimes, bands of argillaceous irony nodules occur.

The lower lias shale, which occurs chiefly in the middle of England, consists of thick beds of dark-coloured and finely laminated shales, in which are calcareous bands and concretions. This, which forms the base of the series, graduates downward into a whitish sandstone, thus united with the upper beds of the new red. This formation, about six miles in breadth, ranges in a *north-easterly* direction from Lyme Regis on the *coast of Dorset*, to the coast of Yorkshire, near *Whitby*. (*Ansted*, pp. 389 and 390.) The lias

forms generally broad and level plains along the foot of the oolite hills, very seldom presenting an escarpment. Only on the borders of Nottinghamshire and Leicestershire does it form a well-marked range, known as the Wold Hills. Its estimated thickness is 500 feet. At Barrow-on-Soar it is extensively quarried and converted into a lime, which has the property of setting under water.* Those beds of the lias which contain calcareous or siliceous matter, are used for walls, slabs, and flooring, and even for buildings, especially at Bidford, near Stratford-on-Avon. The finely figured marble called the Cottam, or landscape marble, is found near Bristol, in this formation.

"In the state of Virginia, thirteen miles east of Richmond, U. S., there is a regular coal-field occurring in a depression of granitic rocks," overlayed by the oolite and lias, in which the coal is found. "One of the seams," says Sir C. Lyell, who examined it, "is in some places from thirty to forty feet thick, composed of pure bituminous coal, and found at a depth of 800 feet." This is the first instance of coal being found of such purity and thickness so high up in the series of rocks. The plants here are specifically different from those of the lower coal-beds.

The chief fossils are Spirifer Walcotti, Plicatula spinosa, Pecten æquivalvis, Plagiostoma giganteum, Ammonites Bucklandi, and Margaritatus, belong to the upper Oolite; Belemnites pistilifor-

* In this quarry, in 1840, the Ichthyosaurus communis was found by Sir P. Egerton.

mis, and acuarius,* Gryphæa, incurva, Nautilus truncatus, &c., a sea-urchin, Diadema Bechei, also occurs belonging to the radiata. Fishes scales of Lepidotus gigas, and teeth of the Acrodus nobilis, and Hybodus, reticulatus, are found in the lias of England, France, and Germany. The most remarkable are those gigantic fish lizards, called the Ichthyosaurus, and Plesiosaurus. The Ichthyosaurus platyodon, now in the British Museum, must have been about twenty-four feet long, and a Plesiosaurus eleven feet long, is in the same collection. These may be considered the police of the ancient seas, as the sharks now are in our own, the remains of undigested fishes being found within their skeletons. Entire dragon-flies have been found in Gloucestershire, and several species of the fossil plant Zamia. The Pecopteris Whitbyensis, and Equisitum columnare, are found in the Virginian coal-shale; also fossil fish, Tetragonolepis, and Dictyopyge, and a

* The Belemnite is simply the stony internal part of a species of ancient cuttle-fish, called the osselet, or gaurd, which contained within its upper part a conical chambered shell, as a float, termed the phragmocone, a horny enlarged prolongation of this upwards, formed the receptacle for the ink bag, all inclosed in a soft or fleshy body, with its collar, head, and eight arms, or tentacula. So perfect was the colouring matter, or sepia, found within these ancient ink bags, that the late Sir Francis Chantry was asked by Dr. Buckland to prepare a drawing with it, which, on being shown to a celebrated painter, was pronounced by him to be sepia of the first quality, *and begged to know* by what colourman it was prepared. *Millions of these* remains are scattered throughout *the lias and oolites*, &c.

species of minute bivalve crustacean, exist in profusion in these shaly beds. In the same beds occurs a reptile called Teleosaurus, allied to the gavial, or crocodile of the Ganges.—(Lyell's El. p. 285, 4th. Ed.)

OOLITIC SERIES.*

This great series of rocks forms a magnificent range of hills of great extent, and, in this respect, is to the south of England what the great Penine, or gritstone range, is to the north. From the coast of Dorset it stretches in a north-easterly direction to Scarborough, on the coast of Yorkshire.† Its lofty and bold escarpments everywhere throughout its course overhang the plains of the lias, and new red sandstone. At Cleevedown Hill, near Cheltenham, it attains the height of 1200 feet above the sea level, and Rosebury Topping, in east Yorkshire, is upwards of 1000 feet, and has an average breadth of nearly thirty miles, which is divided into three distinct ridges, with fine valleys between, the most westerly

* It is sometimes called the Jurassic Group, because it is highly developed in that part of the Alps. The Oolite there is highly contorted, and thrown up to the height of 4000 feet. There, as in England, the lias forms the base of the system.

† The southern portion of this range, which is cut off by the plain of the Humber from the Yorkshire portion, is known by the name of the Cotteswolds, or Gloucestershire Wolds; and the northern, the Cleevedon and Hamelton Hills, or the Yorkshire Wolds. In these Wolds the celebrated Kirkland cave exists, in which were found numberless fragments of fossil bones by Doctor Buckland.

ridge being the highest, and yet the lowest in the series. These consist of the

Lower. Inferior Oolite.
Fuller's earth.
Great Oolite and Stonesfield slate.

Middle. Oxford clay.
Coral rag.

Upper. Kimmeridge clay.
Portland stone and sand.

The lower deposits lap over the great plains of the lias on the west, and on the east the upper green sand usually forms a low escarpment, capping the uppermost beds of the Oolitic series, whatever they may be. On proceeding from London to Cheltenham, (per road,) after descending the chalk range east of Oxford, the whole of this series of rocks would be passed over. The latter part of the journey would be over the high points of the inferior and great Oolites, and then a party would rapidly descend into the plain of the lias, on which Cheltenham stands.* On travelling eastward from Paris to Metz, the geologist would pass over a similar succession of rocks intervening between the tertiary strata and the lias; with this difference, however, that the escarpments of the chalk, upper, middle, and lower Oolites, face towards the east instead of the west.—(Lyell, El. p. 259.)

* *The mineral springs of Cheltenham, Gloucester, Leamington, Bath,* Glastonbury, and Ashby-de-la-Zouch, *through this* formation.

Of the lower members of the Oolitic system, the great Oolite is the most important, both in thickness and practical utility. It is rich in fossils, and contains from forty to fifty feet of good building-stone, sometimes called the Bath Oolite. Its representation in France, (Normandy,) is the well-known Caen limestone, of rather a finer grain, and of a pale cream colour.* The great Oolite is separated from the inferior Oolite, by a few marly beds, containing amongst them a peculiar kind of clay used in the manufacture of cloth, and called "fuller's earth." This earth is chiefly found at Odd Down, and on the side of Midford Hill, near Bath.—(Ansted, p. 386.) The Bradford clay, (Wilts.) is the succeeding division above, which contains that beautiful fossil, the Apiocrinus rotundus, or pear Encrinite. In this division also occurs the dirt bed, as it is called, consisting of black mud, in which multitudes of these Crinoideans, or stone-lilies, are imbedded. The next is the forest marble of Wiltshire, and the uppermost bed is the cornbrash,† which consists of clays and calcareous sandstones, and

* This is largely imported into this country for the purposes of sculpture; tablets, monuments, chimney-pieces, &c. are made of it, and sometimes figures. That of Mary Queen of Scots in the great hall at Hardwick is in this stone. In Normandy it is extensively used as a building-stone. It hardens by exposure to the atmosphere.

† The cornbrash is frequently absent, as well as the Bradford clay, neither being continuous throughout the series. They sometimes replace each other. The name of Bradford is given, because the clay attains its greatest development near Bradford wells. So of the Kimmeridge *clay, from the* village of that name, in the isle of Purbeck.

passes downward into the forest marble, an argillacious limestone abounding in marine fossils. The sandstones of this marble are sometimes ripple-marked, and fissile. Slabs of this fissile Oolite are used for roofing, and called "tile-stones." The Cornbrash is probably so called from its great fertility in producing corn.

MIDDLE OOLITE.

The next, or lower member of the middle Oolite, is the Oxford clay, 500 feet thick, in which occur, in great abundance, Cephalopoda of the genera Ammonite and Belemnite. One, the Ammonites Jason, is very singular, being furnished on each side of the aperture with a single horn-like projection, and was discovered in the cuttings of the Great Western Railway, near Chippenham. One of the limestones of the middle Oolite has been called the Coral Rag, because it consists, in part, of continuous beds of petrified corals, nearly retaining the position in which they grew at the bottom of the sea. They belong chiefly to the genera Caryophyllia, Agaricia, and Astrea, and sometimes form masses of coral fifteen feet thick. (Lyell, El. p. 260.) "Part of our island," says Professor Ansted, at the time of this deposit, (coral rag) "has clearly existed in the condition of a coral island in an open sea."

UPPER OOLITES.

The Kimmeridge clay,* the lower member,

* The bituminous part of this clay, or shale, is used in the Isle of Purbeck, as a fuel called Kimmeridge coal. That known as the Brora coal, in Sutherlandshire, N. B., and long worked, is in the same measure.

consists in great part of bituminous shale, sometimes forming an impure coal, several hundred feet thick, and containing Ammonites, Oysters, and other marine shells. The celebrated lithographic stone of Solenhofen, in Bavaria, belongs to one of the upper divisions of the oolite. This is an exceedingly fine-grained fissile limestone, of a rich cream-colour, and exported to most parts of Europe for the purposes of lithography.

The uppermost bed of the group is the well-known Portland stone, so admired as a building-stone, of which many of the principal edifices of London are constructed. St. Paul's is built of the same upper beds, but the stone was brought principally from the quarries near Burford, in Oxfordshire. Among the most remarkable fossils found in these, or any other kind of rocks, are the fossil skeletons of the Pterodactyl, a species of flying lizard, constructed like a bat, but of large size, and furnished with an enormous bill, filled with formidable teeth, sometimes sixty in number. Seven varieties of these have been found.* Six saurians, three tortoises, sixty species of fish, forty-six of crustacea, and twenty-six of insects, have been found in the oolite. One of the insects is a Libellula, or dragon-fly.

The chief fossil shells, are Gryphæa virgula, Terebratula *digona*, *spinosa*, and *globata*,

* Pterodactyles have been found chiefly in the quarries of the lithographic limestone of the jura at Aichstadt and Solenhofen. They have also been found at Lyme Regis, and in the oolitic slate of Stonesfield. The largest is about the size of a cormorant.—Bridgewater *Treatise, p. 223.*

Pholadomya fidicula, *Astarte elegans*, Ostrea deltoidea, and *marshii*, Trigonia gibbosa, Nerinæa Goodhallii, Turbo costarius, Pleurotomaria reticulata, and *ornata*, Ammonites *striatulus*, (lower Oolite) *Apiocrinus rotundus*, or stone lily, *Berenicea diluviana*, Ammonites *Jason*. Belemnites *Puzosianus*, and *hastatus*, *Cidaris coronata*, *Diceras arietinum*. Corals—*Eunomia radiata*, *Caryophyllia* annularis, Columnaria oblonga (middle Oolite). The wing-covers of beetles have been found perfectly preserved. Bones of reptiles, and the jaws and teeth of Amphitherium Prevostii, and Broderipii, also Phascolotherium Bucklandi. These are allied to the existing opossum and insectivora (Stonefield slate). A few plants have been found, the Pterophyllum comptum, Phlebopteris Brownii, &c.

The structure of the oolite is very peculiar, being generally composed of myriads of minute spheres, balls, or egg-like grains, aggregated together, very much like the roe of a fish; hence the term Roe-stone sometimes applied to it, from ὠὸν, oon, an egg, and λιθος, lithos, a stone. When these assume the size of a pea in the rock, it is called Pisolite. It is supposed to have been formed in seas charged with lime, and that the lime formed in concentric circles round minute fragments of shell, or grains of sand.

We have already observed (page 101) that in Virginia, U. S., coal has been found in the lower *members of* this formation of great thickness and *good quality, but* this is not the case in England. *bed or two* occurs, but of very inferior quality,

and not worth working. But there is a vein of iron ore near Northampton, which is very productive; and the ore is forwarded per rail in quantities to Derbyshire and South Stafford to be smelted. The Oolite is truly a great agricultural district, producing some of the finest corn in England, and abounding, as it does, with good materials for building, the towns, villages, and farm-steadings are substantially built, and have generally one uniform character throughout, frequently with gabled roofs, and mullioned windows.

SPRINGS.—The head of the Thames takes its rise at what is called the Seven Springs, within 3½ miles of Cheltenham, on the south-eastern slope of the great Oolite, and close to the old London road from Gloucester.

WEALDEN GROUP.—This group, consisting of the Weald clay, Hastings sand, and Purbeck beds, was designated by the common name of Wealden, because it was first studied in parts of Kent, Surrey, and Sussex, called the Weald; and the late Doctor Mantell has shown in his Geology of Sussex that the whole group is of fluviatile, or fresh-water origin, a fact of great interest when we consider that it underlies marine deposits of such great thickness as the cretaceous system, or chalk. Doctor Mantell, to whom we are indebted for the most detailed account of the Wealden, describes it as a "series of clays and sands, with subordinate beds of limestone, grit, and shale, containing fresh-water shells, terrestrial plants, and the teeth and bones of *reptiles* and fish; univalve shells prevailing in

the upper, bivalves in the lower, and Saurian remains in the intermediate beds, the state in which the organic remains occur manifesting that they have been subject to the action of river currents, but not to attrition by the waves of the ocean."

The Purbeck beds which repose on the Portland oolite, have long been well known, having been quarried for many years (centuries,) for ornamental purposes and as a building stone.* The marble bed is of a greenish colour, owing to the presence of chlorite, and abounds with the remains of a univalve shell, the Paludina.

Another variety of shelly limestone, called the "Sussex Marble," was, like the Purbeck, used for small insulated shafts of pillars, and other ornamental work so common in Gothic architecture.

What is termed the dirt-bed, occurs in the Purbeck beds, a submerged forest, the stumps of the trees being found in a kind of black soil—hence the unsavoury name given to it. Zamia and Cycas are also found in this bed.

The Hastings sand (middle bed,) is of a friable nature, but sometimes sufficiently compact to form a good building stone. In the neighbourhood of Tunbridge these beds are strikingly developed in what are termed the Bell Rocks; also in the cliffs of Hastings. The upper bed of the

* Old London Bridge was built of this stone, and it was also extensively used for ornamental works, pillars, *&c. in the abbeys* and other buildings throughout the *kingdom. Furness* Abbey contains pillars of this marble *still in good preservation.*

Weald consists chiefly of blackish clay. The whole series is stated by Sir C. Lyell to be from 700 to 800 feet thick.

The principal fossil shells belong to the genera Melanopsis, Melania, Paludina, Cyrena, Cyclas, Unio, Modiola, Avicula, Thracia, and Limnea. The Cypris, a shell belonging to the Crustacea, is plentifully scattered through the clays of the Wealden. A fern, Sphenopteris gracilis, is found near Tunbridge Wells. The fishes of the Wealden belong partly to the genera Lepidotus, Pycnodus, and Hybodus.

The great Iguanodon, an herbivorous reptile, from 30 to 40 feet long, was first discovered by Doctor Mantell in this formation. Also another gigantic animal, the Hyleosaurus, with remains of Testudinata of the genera, Trionyx and Emys, (now confined to tropical regions,) were found in the calcareous sandstone and grit of Tilgate forest, near Cuckfield.

CRETACEOUS SYSTEM.

This system, or the great chalk ranges, occupies the south and south-eastern parts of England, forming what are called the Downs, which, stretching from the borders of Wiltshire on the west, run out into two spurs to the east, one proceeding along the south coast, forming the South Downs, and terminating at Beechy Head, and the other forming the North Downs, and extending to the sea at Dover, the Tertiary deposits of the London and Hampshire basins cover up and conceal much of the deposit. To the *north it* extends into Yorkshire, where it termi-

nates eastward in Flamborough Head. It is seen again in Denmark, Belgium, and France, inclosing as within a circle the great Tertiary deposits of the London and Paris basins. In the North Downs it attains the height of nearly 1000 feet, and it forms the lofty cliffs of Dover, (600 feet,) Beechy Head, the back of the Isle of Wight, the Needles, between it and the mainland, and the high cliffs on the coast of France. It also appears in Germany, Poland, Russia, the Crimea, and other parts of the world.

The chalk being generally of a loose and soft nature, its contained fossils, of which there are many, are obtained in their greatest perfection, the spines of the most delicate being found quite perfect. The chalk is well known as containing numerous beds of flints interstratified with it. This occurs, however, only on the upper, or white chalk; the middle, or lower chalk, or clunch, contains no flints. Beneath this occurs the chalk marl, or grey chalk, which is harder than the white, and partly argillaceous and siliceous; whereas the upper is nearly pure carbonate of lime, containing lime 56·5, carbonic acid 43·0, and water 0·5. The grey chalk rests on the upper green sand, which partakes of a still more argillaceous and siliceous character than the marl, the limestone passing into a calcareous sandstone, coloured by silicate of iron. This variety is quarried near Reigate, in Surrey, as "firestone," which is a valuable lining for fire-places and furnaces. Blackdown Hills, a remarkable *outlier in Devonshire*, are capped by a variety of *the green* sand to the amount of 100 feet,

which is quarried or mined for whetstones. The fossils from these workings, to the number of 150 species, are converted into chalcedony, and are often in fine preservation.

The Gault, a provincial term, meaning brick-clay, is a stiff clay, of a blue colour, the inferior portion of which abounds with iron pyrites, (frequently very brilliant,) while the upper part contains green particles of chlorite, or silicate of iron. This bed intervenes between the upper and lower green sands.

The lower green sands consist of many beds of white and green sands, alternating with many clays, and then succeeds the bed sometimes called the Kentish limestone, or Kentish rag, which is of considerable value for various purposes, being used chiefly as a rough building-stone; and having somewhat of a wide range in the south-east of England—the thickness of these beds at Hythe is 400 feet, but it is nearly double that at the back of the Isle of Wight—the upper cretaceous rocks are sometimes burnt into lime, or mixed with other soils for agricultural purposes. The united thickness of the chalk series is about 1000 feet.

Among the fossils found in the upper beds are many Infusoria and Foraminifera, and numerous small corals; many species of sea-urchin, (Ananchytes ovata,) &c.; Rudistes, Crustaceans, fishes, and reptiles. We proceed to give a few of the chief fossils:—Baculites Faujasii, and anceps. This latter is a long-pointed shell, like a straight Nautilus, but showing distinctly crenulated, or toothed *septa*. (It belongs to the Cephalopoda.)

Belemnites mucronatus, and Listeri, Turrilites costatus, Terebratula plicatilis, pumilus, lyra, and carnea, (upper white chalk,) Crania Parisiensis, Ostrea vesicularis, and carinata. Pecten costatus—Plagiostoma Hoperi, and spinosum, (spined shell,) Scaphites striatus, Inoceramus Lamarckii, and Cuvieri. Eschara disticha and Hippurites Mortoni, and organisans, Ammonites Rothomagensis, (green sand,) Hamites spiniger, and Perna mulleti. Coprolites of fish have also been found.

Fish of the genera Lamna, Galeus, and Carcharias, are common to the European cretaceous rocks, and the North American. A beautiful group, (six in number,) lying across each other in a mass of chalk scarcely above a foot square, the author saw at a friend's in London in 1854. They had been just found in white chalk to the south of London.

The head of the Mosasaurus, a gigantic reptile, 25 feet long, allied to the Monitor of the present day, was found (1780,) in the upper chalk called the Maestricht Bed, in Belgium.

M. Bronn estimates the total number of the chalk species of fossils at nearly 3,000.

The flints in chalk, of which there are multitudes of every possible variety of form, are generally supposed to have been sponges; Ventricolites labyrinthicus and flexuosus are varieties; others contain aggregations of fossil Infusoria and Foraminifera. The latter are extremely minute chambered shells.

The chalk, when examined by the microscope, *found to be* one entire mass of broken shells

and corals.* It is found that a white powder, like chalk, is deposited within the lagoons formed by a coral reef arising from its destruction, and even worms, it is said, exude this white chalk.—Lyell, p. 216.

We give below the English and foreign series together, as arranged by Professor Ansted, page 371.

ENGLISH AND BELGIAN SERIES.

Maestricht beds, Belgium upper chalk, with flints.

Middle and lower chalk (without flints) and Clunch.

Chalk Marl.

Upper green sand.

Gault.

FRENCH SERIES.	GERMAN SERIES.
Terrain senonien.	Upper Quader sandstone.
Terrain turonien.	Upper Pläner limestone.
a. Craie Chloritée.	Middle Pläner.
b. Glauconie crayeuse.	Lower Pläner.
c. Graie tufau.	
Terrain Albien.	

* We have only to brush a piece of chalk in water, dry the particles thus obtained, and examine the residuum with the microscope, and we shall find it consisting of minute shells, corals, or fragments of them.

CHAPTER VI.

TERTIARY EPOCH.

THE name of Tertiary has been given to this series of rocks because it is all posterior in date to those termed secondary, of which the chalk constitutes the newest group. This series was specially divided into three, in consequence of finding a difference in the recent and extinct species of fossils, and as indicative of a new era dawning on the world. Hence the term "Eocene (Greek,) was applied to the lower, from eōs, the dawn, and cainos, new. So also Miocene, to the middle, from meiōn, less, which indicates, that although the proportion of recent species is more considerable than before, it is still less than one-half; while the appellation Pliocene, from pleiōn, more, is given to the lower beds, where more than half the species are recent."—(Ansted, p. 339.)

The term Pleistocene, being a nearer approximation to the present time, has been more recently applied to the Drift period, which overlies all the preceding; and Post-tertiary to raised beaches, Peat bogs, submerged forests, &c. belonging to a still more recent period—a period, in fact, in which nothing but recent species are found.

The beds of the Eocene period are found in England, chiefly in the basin of the Thames, (*London* basin,) in Hampshire, near Southampton, *and the Isle* of Wight. "On the continent, *beds near* Paris are of the same age, but are

totally different in mineral character." Brussels, also, is built on similar deposits. In the Paris basin is a series of fresh-water sandy beds, called the Fontainebleau, some containing gypsum; then succeeds the middle beds below these, called the "grès de Beauchamp," amounting, in all, to 280 feet, which are not found in England; but the following beds, called "Calcaire grossier," and "Glauconie grossière," which are not extensive deposits in the Paris basin, are represented by the far thicker and more extended sandy and clayey deposits of the upper part of the Hampshire system, and in the basin of the Thames, by the Bagshot sands; after which we have the London clay in the latter, and the Bognor beds in the former district, and the mottled clays and sands on which these repose, representing, on a grand scale, the lower sands of the Paris basin. The gypseous series of that basin consist of a siliceous limestone alternating sometimes with green marl. "These contain fluviatile shells, fragments of wood," vast numbers of bones of fish, of crocodiles, and other reptiles, of birds, and even of quadrupeds. "The gypsum beds of Paris have been extensively quarried, to be converted into plaster of Paris, (obtained by burning the gypsum,) and have yielded a multitude of mammalian remains of Palæotherium, Anoplotherium, Cheropotamus, fresh-water Tortoises, Trionyx, Emys, and Crocodile; also extinct species of birds, fishes, &c. Silicified trunks of palm-trees are found in the beds associated with the gypsum. The coarse limestone of the '*Calcaire grossier,*' which often passes into sands, and

clayey, and calcareous marls, and hard limestones, contains nearly 1,000 species of shells; and amongst them not less than 140 species of one genus, the Cerithium, (a univalve,) some of which are upwards of a foot in length."—(Ansted, p. 361.)

The fluvio-marine and fresh-water beds of the Hampshire basin are best exhibited in Alum Bay and White-cliff Bay, (Isle of Wight,) where they form a large series of sands, clays, and limestones, containing fossils. These bays present the most striking phenomena of sands and clays of the most varied tints, as green, yellow, red, crimson, ferruginous, white, black, and brown, all now placed vertically, by volcanic action, to that of their original horizontal position.

The London clay, called the "plastic," (Argile plastique of the Paris basin,) consists of a series of mottled clays, sands, and pebbles; but the middle part of the London clay is of a dark colour, often mixed with greenish-coloured earth and white sand. These beds contain nodules of a clayey limestone, called "septaria," which are traversed by veins of calcareous spar. These are abundant in the neighbourhood of Harwich, and made into a kind of cement. In Italy, Asia Minor, Egypt, and India, occurs a remarkable rock of the same age, containing vast quantities of Nummulites,* a genus of Foraminifera. It is thus called from its likeness to a piece of money. Numerous remains of fishes are also found in the same formation. The remains of plants in the

* *Some of the* Pyramids are built of Nummulitic lime-

older tertiary beds are chiefly fruits, and obtained almost entirely from the London clay beds of the Isle of Sheppey.

The middle tertiary period is not so strikingly developed in the British Islands as on the continent, in Asia Minor and North America, &c. The Coralline Crag, on the coast of Suffolk, is the most important, chiefly for remains of Zoophites, referable, for the most part, to species unknown in the living state. These are most abundant, and found with Echinodermata, and shells. Above 340 species of Mollusca have been collected in it, of which 73 are living British species. A jaw of Dinotherium, and a tooth of Mastodon, have been found. In the neighbourhood of Paris there are large deposits of this period, in which are found remains of shells, such as Limnea, Planorbis, with the seeds of Chara. The celebrated French bhurrs, for millstones, occur in this formation. This is a siliceous material, not unlike the white porous cherts, or china-stone, found in the Bakewell quarries, Derbyshire.

NEWER TERTIARY PERIOD.—This is chiefly developed in England on the coast of Suffolk, part of Norfolk, and Essex. It consists of a deep ferruginous-coloured gravel, abounding in fossil shells. This is called the Red Crag. Professor E. Forbes states that there have been found in it 260 species of Testacea, of which 60 are now known alive in our present seas, 41 of this number are Pleistocene. In Italy it is largely developed on the flanks of the Appenines, and consists of marls, sand, and calcareous matter, said

to amount, near Parma, to 2,000 feet. This deposit is found in Sicily under the name of the Great Limestone. Lignite, or brown coal, occurs in it in various parts of Germany, where also exists a thin, leafy, bituminous lignite, called Paper-coal; also fragments of silicified wood, often changed into chalcedony, and sometimes into semi-opal. The lignite is remarkable for the fossils associated with it, which consist of the remains of Insects, Mollusca, Fishes, Batrachian reptiles, and even of quadrupeds. The Pliocene strata occupy a very extensive region in southern Russia, and are seen in the cliffs of the Sea of Azof, where beds of white and yellow limestone contain species of Cardium, and large Mactræ, all of marine origin.

Pleistocene, or Drift Period.—Under the general term drift, Professor Forbes includes:—1. Glacial beds of sands, gravel, &c. often stratified. 2. Till. Unstratified clays and gravels, with boulders. 1. The Mammaliferous, or Norwich Crag, which includes fossiliferous sands, shingles, and loam; and lastly, fresh water beds of sands, marls, and gravels. The newest of these includes gravel, erratic blocks, and the boulder formation originally called Diluvium. The general opinion now prevails that these erratic blocks, (some of immense size,) boulders, and gravel, have been transported by Icebergs, and distributed over all the countries where they are now found, and some, to a limited extent, by *glacial action*, brought down into the valleys and *plains of Alpine* districts by the melting of the *snow and fall* of avalanches. The number of

Icebergs floating in our present seas, of immense size, sometimes hundreds of feet in height and depth, and miles in extent, show the transporting powers of these colossal masses when loaded with materials riven from their parent rock by volcanic and other destructive agents, and rolled down upon them over long periods of time.* The Till is generally called "Boulder clay," it

* Many icebergs, seen floating by Captain D'Urville of the French exploring expedition in the Southern Ocean, "were carefully measured by him, one of which was found to be thirteen miles long, and 100 feet high." "Captain Scoresby counted 500 of these in latitudes 69 and 70 north, which rose above the surface from the height of a 100 to 200 feet, and measured from a few yards to a mile in circumference. Many were so loaded with earth and rock of such thickness, that the weight was considered to be from 50 to 100,000 tons. Specimens of the rocks were obtained, and among them were granite, gneiss, mica-schist, clay slate, granular felspar, and green-stone. Hence, when this floating ice is dissolved, the materials on it would be deposited at the bottom of the ocean; and if that ocean were subject to strong currents at the time, these materials would assume a stratified appearance; but if not, they would lie in a confused heap, a circumstance which has been often observed in regard to these rocks. In cases of drift too, the lighter materials are transported the farthest, and the heaviest to the least distance. It may be observed, also, that formations from drift have their largest, broadest, and coarsest end towards that point from whence the materials come, and at the reverse end generally terminate in a point, or feather out. This may be sometimes clearly seen where the eye can command a view of the whole formation. The diluvial gravels, which extend so widely in Northern Europe, are met at the foot of the Ural mountains by remarkable auriferous alluvial deposits, whence have been obtained, for many

being of a clayey nature, and very widely spread. The Norwich Crag is a local deposit, and this, with the fresh-water deposits, are not extensive in England; but in Scandinavia, Denmark, and Northern Germany, there are extensive deposits. They exist in some one form or other, more or less, in every part of the world in similar positions.

The RECENT PERIOD has reference to raised beaches, of which there is abundant evidence in the neighbourhood of the great North American lakes, valley of the Mississippi, around parts of our own shores, and in the Baltic, &c. These arise partly from the violence of the waves, and from the gradual elevation of the land. The late Sir Henry de la Beche stated that not less than 2,500,000 tons of broken shells, sand, and other materials, were originally thrown up on the beach at the Land's End, Cornwall, by the violence of the waves. During storms, the force of the waves is terrific on these shores. A good deal of this drift is carted away for manure.

Peat bogs are composed of vegetable matter, which grows rapidly in moist situations, and

considerable supplies of gold. It is in similar deposits that the gold is found in Australia, and also in California."—(Ansted, p. 82.) Thus were transported in past times the multitudes of blocks which are scattered over most of the plains of Europe, and elsewhere. A block of granite, of great size, lies in one of the bye-lanes in Manchester.

The splendid granite vase in the centre of the sculpture gallery at Chatsworth was made at Berlin, out of *an erratic block* found in the neighbourhood. It is *twenty feet in* circumference, and stands about five feet high.

they have been sometimes the site of ancient forests. Submerged forests are the result of the subsidence of the land through volcanic agency.

The deposits in Caverns, of which Kirkdale is one, (Yorkshire,) have been washed in through the action of the waves of the sea, or by river floods or lakes. Instances of the way in which the materials of the recent period have been transported and deposited have been already alluded to, (p. 26,) viz. by the accumulations on the banks of rivers during floods, and by what takes place in estuaries, and at the mouths of rivers, by the same agency, even in the present day.

FOSSIL CONTENTS OF THE TERTIARIES.

Eocene Period.—Some of the chief fossils of this series are Orbiculina numismalis, Bulimina Murchisonii, Sagrina rugosa, (foraminifera) Venericardia imbricata, and planicosta, Cardium porulosum, Ampullaria acuta, Turitella imbricataria, Voluta athleta, Terebellum fusiforme, Belosepia sepioidea, Aturia zigzag, Rostellaria macroptera, Crassatella sulcata, Mitra scabra, Nautilus centralis, Cerithium cinctum, giganteum, &c. These, all but three, are bivalve shells. Teeth of species of monkeys, bats, oppossum, &c. and multitudes of Foraminifera, (recent microscopic shells,) so minute, that Plancus collected 6,000 of them in an ounce of sand from the shore of the Adriatic; and D'Orbigny found 3,840,000 in the same quantity of sand from the shore of the Antilles.*

* Some of these are so minute, that 500 of them only *weighed one grain.* Small as these are, the infusoria

Professor Tennant, in his Catalogue of British fossils, gives the fullest account of those in the Eocene period. But a number of species belong exclusively to the Paris basin, so that, as Professor Bronn states in his tables, there are no less than 3,000 species. Of these, 57 are Mammalia, and as many as 136 are referred to the vegetable kingdom, but these are chiefly fruits, as already stated, (page 119.) Many extinct quadrupeds, such as the Paleotherium magnum are found in the Paris basin.

MIOCENE.—In this we find (Univalves) Helix turonensis, Cerithium cinctum, Rostellaria pespelicani, Limnea longiscata, and a remarkable species of palm called Palmacites Lamanonis, &c.

NEWER TERTIARY PLIOCENE.—We have Voluta Lamberti, Murex alveolatus, Fusus contrarius,

exceedingly more minute, for they are often found filling up the minute chambers of these Foraminiferous shells. Such are the myriads of Infusorial beings, or Diatomaceæ, (plants) that they enter largely into the composition of our fine sands and muds. In some parts of the great plain of Northern Germany are deposited more than 60 feet thick of materials chiefly composed of the siliceous cases, or skeletons of Infusoria. They form the celebrated *Tripoli*, polirschiefer, (polishing slate,) of the Germans, which is entirely composed of their cases. Ehrenberg estimated that a cubic line of the "Bilin" contained, in round numbers, 23,000,000 of individuals. In the cubic inch, therefore, the number is immense, for a cubic inch contains 1728 cubic lines. In the waters of the Elb, and elsewhere at the mouths of rivers where *tidal action is* felt, large accumulations of these take *place; myriads* dying at every recurring tide as soon as *they reach the* fresh water.

Cypræa coccinelloides, Trophon elegans, Natica Glaucinoides, (univalves,) and Astarte Omalii and plana, Pecten jacobæus (bivalve) and a gigantic shark, Carcharias megalodon.

Drift Period.—The deposits of this period are remarkable for the abundance of Mammalian remains in various caverns and gravel beds. "The most remarkable of these are the large Pachydermal species, and some large Ruminants, whose bones are common in Western Europe and England, and of which complete carcases have been found in Siberia. The gigantic extinct quadrupeds of South America and Australia, and the birds of New Zealand, speak to the same fact." In the drift of the Northern Hemisphere, we find the Mammoth, or Elephas primigenius, and the Mastodon giganteus, nearly allied to the Elephant; two extinct Rhinoceroses; "extinct species of Hippopotamus; several large Ruminants, among which the Urus is the most interesting; a gigantic Bear; some large feline animals, and a gigantic Hyæna, and Beaver, (Trogontherium) and some whales." In South America we find the great Megatherium, and Mylodon, gigantic terrestrial Sloths; several Glyptodons, or gigantic Armadillos. In Australia the ancient marsupial races were also gigantic species of the existing Kangaroos, Wombats, and other tribes. Several bivalves also occur, all existing at present; namely, Venus mercenaria, Astarte Laurentiana, Mytilus edulis, and Saxicava rugosa. The entire "fauna of the glacial beds, including the Mammaliferous crag, consists

of above 170 species of marine animals, chiefly Mollusca."

The imbedded fossils of the recent period, which occupy large tracts in the valley of the Missipippi, (as before stated,) the valley of the Ganges and the Rhine, where these deposits are called "loess," and in Italy, "Molasse," are all recent, in which we find shells of the Bulimus, Helix, and Pupa; also Limnea, Paludina, and Planorbis, and many skeletons of modern animals—deer, dogs, foxes, &c.; also in England, buried ships in the deserted channels of the Rother in Essex, the Mersey in Kent, and the Thames, &c. as Canoes, stone hatchets, arrow heads, fragments of pottery, and other works of man, all testifying to a recent period. But where are any remains of man? We have examined and passed in review many thousand feet of rocky matter with their embedded fossil contents, but nothing referable to man has appeared. But now behold the remains of him in this last and recent deposit, thus showing that he is only of yesterday—the last, the crowning head of this lower world, endowed with mind, immortal mind, to appreciate aright the glorious works of his great and Almighty Creator. Hence the fossil skeleton found in the recently raised beach in Gaudaloupe, is placed at the extreme end of the fossil series in the British Museum. Thus geology, instead of being hostile to the word of God, as once supposed, presents some of the most striking *evi*dences of its truth, and manifests forth the *wisdom and goo*dness of God in the arrangement [redacted] *deposition* of the strata, the formation of

springs and fountains of water, the vast deposits of coal and iron, distributed in almost every part of the world, with the necessary limestone flux generally in immediate proximity. The precious metals being so reduced to fragments, that they may be obtained with facility, while other metals of lead, zinc, tin, &c. have originally appeared at the surface to tempt man to test their utility, and they are seldom found so deep but that he may obtain them by skilful labour at a moderate expense; besides the immense depositions of vegetable mould which is spread out as a thin covering over the earth, to produce the necessaries, and supply the wants of the human family.

PLUTONIC AND VOLCANIC ROCKS.

The evidence of the existence of the former of these products is widely spread over the earth. The basaltic rocks of the Giant's Causeway, Fingal's Cave in Staffa, Rowly Hill, near Dudley, the Wrecken, near Shrewsbury, the Licky in Worcestershire, the toadstone beds in Derbyshire, and the immense accumulations of greenstone in Auvergne, (France,) in Scotland, and the trap dyke crossing the Durham coal beds, and elsewhere over the world, show to what extent the surface of the earth was effected by Plutonic agency at a remote period; and especially this will be seen when we recollect that all the varieties of granite belong to this class of rocks. Some of these rocks are called trap rocks, from the Swedish word trappa, a flight of steps. These rocks exhibiting a step-like appearance at a distance, which is the case with those of the

Giant's Causeway, &c. But on closer inspection these appear to be hexagonal and pentagonal columns, aggregated or clustered together, and broken off at different heights, but this is all the result of slow cooling under the sea, when the molten matter was thrown out from its plutonic vent. Hence the term plutonic applied to them. These igneous rocks have played an important part in modifying the earth's surface in past time.

The volcanic rocks are those which are now produced on the surface of the earth at the present period, as well as of past time, and consist of lavas of all varieties and colours, scoria, pumice, obsidian, or volcanic glass, volcanic cinders, mud, lapilli, or minuter cinders and dust, sulphur, &c.; and of which we have had fearful evidence in our own day in Etna, Vesuvius, and other volcanoes in every quarter of the world. It is not a long time since Vesuvius was in violent action, and little more than a year since the great volcanic mountain of Jeddo, in the island of Japan, after being often fearfully excited over long periods, fell in, and disappeared from the surface.

Earthquakes result from the same causes, and produce terribly distressing consequences. That of Lisbon, which took place on the 1st of November, 1755, destroyed the greater part of that city, was felt in every part of Europe, and even at Barbadoes, across the Atlantic; the waters of Bath, Matlock, Buxton, &c. were thrown up with [illegible] *violence*, and the miners in Cornwall and [illegible]*shire* heard a grating noise, as if the mines

were falling in upon them. The area affected by it was considered equal to 4,000,000 of English square miles. Space forbids our dwelling longer on these subjects.

The formation of mineral, and other veins, is the result, generally, of volcanic or Plutonic actions by upheaval, &c. The rock is rent in twain, with more or less violence, at different points; hence the veins will differ in width, height, and depth, accordingly. Sometimes they are but a thread in width, while in other cases they open out into wide chasms. These are then subsequently filled in with veined stuff, (as calc, and fluor-spar, barytes, &c.) as the miners term it, and metallic ores, almost always crystalline, and, no doubt, the result of electric agency.

Valleys are considered to be the result of the subsidence and upheaval of the earth's crust, either by repeated shocks, sudden, or gradual, and continued for a length of time; and these valleys are again modified when formed, and the hills rounded off by the action of the sea, oceanic currents, and the effects of rivers. It is known that the coast of the Baltic Sea, especially on the Swedish side, is gradually rising, so that that sea may ultimately become dry, and form an extensive valley.

ECONOMIC GEOLOGY OF ENGLAND AND WALES.

Dr. Buckland commences his Bridgewater Treatise by pointing out three different geological regions into which England and Wales may be divided. "The first, as a thinly peopled region of barren hills and mountains. The

second, as a land of rich pastures, crowded with a flourishing population of manufacturers. The third, as a great corn-field, occupied by persons almost exclusively engaged in the pursuits of husbandry." This is not far from the truth, and we shall take these as the groundwork of our remarks, with expansion, and some modification, besides adding a fourth division to the number.

If we take a good map of England and Wales, especially that made by the Government survey, we shall observe that all the west and north-west parts of the country are laid down as hilly and mountainous, and consisting chiefly of primary strata and plutonic rocks, affording a scanty herbage in the form of sheep-walks and pasturage for cattle for a limited time during the summer months. Only in the narrow valleys between, covered by the debris of the hills, which has been originally carried down by the mountain stream, do we find anything like a rich cultivation. The buildings, too, are usually of a rude construction, and present an aspect of heaviness; and we have known the farmers in these regions to cut and crush the furze, out of necessity, as fodder for their cattle. But these mountains contain, in many districts, rich veins of tin, copper,* zinc, and lead, which latter sometimes yields a vast amount of silver, (native silver, in this country, being seldom found separate.) These metals, and a few other minerals, compensate, in some measure, for the sterility of the soil. Cornwall,

* *The annual yield of copper in Cornwall is upwards of a million sterling.*

North Devonshire, North Wales, parts of Derbyshire, Staffordshire, and the north-west parts of Yorkshire, Cumberland, and Westmoreland, are the districts comprehended in the above description.

As we journey eastward, and descend these mountains, a wonderful difference speedily occurs. Stretched out before the eye of the traveller are vast plains slightly undulated, varied here and there with what may be termed little hills of slight elevation, frequently covered with trees, which add to their picturesque beauty; and on all sides, as far as the eye can reach, are rich pastures, fertile corn-fields, with their multitudes of hedge-rows studded in part with the noble oak and other kinds of foliage, and dotted in places with farm-steadings, villages, and less frequently with towns and cities, those hives of industry, teeming with an active and busy population. Our view comprehends the new red sandstone series, beneath which (especially its northern border) lie the coal-measures and iron-stone pits which are of such immense value to England. This important geological zone extends, with little interruption, from the mouth of the Exe, on the coast of Devon, to that of the Tyne, and crosses the whole of the Midland Counties. Thus it takes a diagonal course nearly throughout the whole extent of England. Along the western and north-western margin of this line its chief manufacturing towns and cities occur, with their vast iron, glass, and other works, exhibiting a multitude of blast furnaces, tall chimneys emitting clouds of smoke and flame. Birmingham

with its foundries of almost every description, producing the deadly instruments of warfare, hardware of every kind, objects of art and vertu in bronze, exquisite glass ornaments, toys, &c.; Coalbrook-dale with its beautiful porcelain; Derby, with its machinery, silk works, galloons, iron castings, &c; Nottingham, with its lace and hosiery; Sheffield, with its splendid cutlery; Leeds, with its fine woollens and cloths, and other towns besides, are all on this line. One splendid offshoot occurs to the west of this, the great city of Manchester, with its vast cotton manufacture, and the first shipping port in the world, Liverpool, contiguous to it, containing about a million of people between them, are also on the same formation. Years ago there was a great sameness in the buildings of this extensive district; being chiefly destitute of durable building-stones, the inhabitants used bricks for their buildings, and tiles for roofing. Then the streets, or roadways, were formed of the hardest materials they could obtain, but made chiefly of gravel; and the pathways of the hard siliceous boulders found in the neighbouring gravel-pits, which abound throughout these districts, the latter most uncomfortable indeed to the foot-passenger, but better than mud in wet weather. When the canals facilitated traffic, these began gradually to disappear. But since the railway system extended itself as a network over the kingdom, the aspect of all the great towns is wonderfully *altered.* Now we have splendid buildings, fine *streets with* broad pavements, and every comfort *in this way* that man can wish. And what is

the cause of the change? Simply this, that we are now furnished with a cheap and ready communication with all those districts which afford durable building-stones, so that we can press into our service the Welsh slates for roofing, the Llandeilo (South Wales) and Yorkshire flagstones for paving, the granites for our streets as well as buildings, and the gritstones of the Penine chain, magnesian limestones of the Permian system, and Oolitic freestones, for our buildings. Bricks are still used extensively, because, in some places, the cost is less. But how different the style and taste of the houses, a great portion of them having in-bands and out-bands of stone, with sills, sidings, and lintels for the windows and doorways of the same.* Only now in the old and unimproved towns do we find the rough traces of the past. Increased wealth, no doubt, has contributed much to this agreeable state of things.

We now proceed to consider our third division of the subject, and here we shall also have cause to be thankful for another geological band, or zone, of considerable beauty, great fertility, and extent, which stretches across the kingdom, and that is the great Oolitic system, which may be termed the great Corn-field of England, containing some of the finest and most extensive farms to be found anywhere. This Zone, having an average breadth of thirty miles, extends from the coast of Dorsetshire in the south, to the coast of Yorkshire in the north-east, occupying the whole

* The under coal-clay, sometimes called the fire-clay, affords *great facilities* for making bricks over this region.

of that coast from Scarborough to Redcar. Over the whole of this district building-stones are plentiful; hence the towns, villages, and farm-steadings have nearly one uniform character, especially the older and less improved. Gloucester, Stroud, Cirencester, Banbury, Stamford, Lincoln, &c. exhibit their gabled fronts, and other antiquated forms long in use. The village and farm-buildings are of a similar structure, but all of the most substantial nature. Gloucester, Ely, and Lincoln Cathedrals, are built of the Oolite. The greatest difficulty here was to procure material for the roads, for the Oolite, like the gritstone, is speedily crushed by the carriage wheel.* We have often seen, what was once termed the great North road, from Stamford to Newark, terribly rutted by the immense traffic and the want of hard stone. Now here, as elsewhere, the railways, while they relieve the traffic on the roads, furnish also the facility for bringing a durable material for the roadways. As in some of the carboniferous limestone districts, stone walls are common, and hedges less so. The springs are abundant over the whole region, being thrown up by the lias in the lower part, and the fullers' earth and clay beds in the higher. The Oolite is wholly an agricultural, and not a mining district. One bed of inferior iron ore is found in it of considerable extent, which is worked, and the ore sent into the mining districts to be smelted.

The fourth, and last division, comprehends the

* *Cheltenham* and neighbourhood used to be supplied with the *Bristol* limestone, brought as ballast to the port of *Gloucester*.

Cretaceous region, or chalk, and the Tertiary, or London clays and sands. Now here we find no durable building-stones. Hence brick buildings generally prevail. But frequently the main part of the buildings consist of a strong wooden frame-work, filled in with bricks, and sometimes only with laths and plaster, which give to the towns, villages, and farm-steadings, an interesting and highly picturesque character, and, with the abounding foliage and air of neatness everywhere, the villages often present an aspect of rural beauty not to be found in other parts of the kingdom. On the London clay the out-farm buildings are almost all constructed of wood. Some of the buildings are formed, though rarely, of flints alone, but they are more frequently used to fill in as ornamental work. These flints, when broken up, form admirable materials for the roads and highways. The extreme north and western margins, or outcrop of the chalk, as well as parts about Cambridge, Newmarket, &c. also the South Downs, are sterile, but its inner boundaries are highly productive, and most of the Tertiaries are also very fertile.

SPRINGS.

The springs on the chalk are derived chiefly from the green sand, which is the base of the system, from whence also must be obtained the pure water supply to all within the chalk basin, for the London clay is impervious to the water, and what is obtained above it, arises from the gravel-beds, where they exist; but this source is *limited*, and in dry summers fails altogether.

Hence many of the wells in London are deep, being sunk through the London clay and chalk down upon the green sand. The fountains in Trafalgar Square are derived from this source.

The cause of this is obvious, from the fact that the outcrop or bassets of the chalk and green sand are found at a high angle, south, west, and north of this basin; so that the greater part of the rain which falls on this extensive circle of hills naturally drains downwards beneath the London clay. All springs result from similar systems of drainage, but some issue from natural openings on the hill sides, or in the valleys, where the water is checked by meeting with *impervious strata;* or, in other cases, it is sometimes thrown up to the surface by Faults occurring in the measures.

These few remarks may help to show that the external conditions and aspects of a district or country depend entirely on its geological character. Hence a knowledge of this science, to some extent, at least, is necessary to landed proprietors, miners, farmers, builders, engineers. &c.

HEIGHTS AT WHICH FOSSIL SHELLS ARE FOUND.

"Fossil shells, of forms such as now abound in the sea, are met with far inland, both near the surface, and at great depths below it. They occur at all heights above the level of the ocean, having been observed at elevations of 8,000 feet *in* the Pyrenees, 10,000 in the Alps, 13,000 in the *Andes,* and above 16,000 feet in the Himalayas."—*Lyell,* El. 4th. Ed. p. 4.

HOW TO OBSERVE GEOLOGY.

The geological student, in travelling, ought always to be on the look-out to behold the aspects of the country. For instance, supposing he is in London, and intends to travel west or north—take the Bath route for instance, by road or rail—the moment he leaves the flat or low grounds of the Tertiaries, or London basin, he will have to cross the chalk ranges, the highest of which is about 1000 feet, (Bexhill,) a broad valley succeeds these, composed chiefly of the Oxford and other clays; and then, if he looks out well ahead, he will observe the bold hills of the superior and inferior Oolites to the north-west of him, the highest of which is about 1,200 feet. The Great Western Rail is carried completely through the rocky gorges and defiles of these mountains before it can reach Gloucester or Cheltenham; but on proceeding to Bath, a vast deal of cutting and tunnelling was required to reach that city and on to Bristol, where these measure are succeeded by the new red sandstone and the carboniferous limestone. Some magnificent views are obtained by the old coaching-roads over these districts.

But the Great North-Western furnishes the greatest variety of geological phenomena, for on this line we have not only to cross the chalk hills and for thirty miles of the Oolite, but after passing the Blisworth cutting, made in the Oolite, we have a long stretch of the New red sandstone to cross before reaching Derby on the one hand, or Birmingham on the other; and proceeding from the latter *city* to Dudley, &c., we are carried

amongst the Carboniferous and Silurian series of rocks, with here and there outbursts of trap rocks on either hand; then proceeding onward by Shrewsbury into North Wales, we should find ourselves landed amongst the primary strata in the great slate system of Snowden, or North Wales.

In making excursions through the country, the student will obtain much correct information of the nature of the rocks over which he is passing, if he carefully examine the stone walls and common buildings; for he may be assured of this, if there is any stone in the neighbourhood, the people will avail themselves of it for such purposes. For instance, on the Lias the thin slates of considerable size, which are obtained in all the quarries of this measure, are used for fencing about their buildings and farm-steadings. The thicker beds are also used for building, and the Lias is so regular in this respect, that there can be no difficulty in detecting it. In the Peak of Derbyshire the walls are a certain test of the presence of the Toadstone bed, although a basset of it may nowhere appear, for the stone walls are sure to be constructed of limestone and dark toadstone boulders wherever the toadstone comes up to the surface. This is merely thrown out as a hint to the traveller, that he may, if he likes, derive practical knowledge as he proceeds either on journeys of pleasure or of business.

QUESTIONS.

CHAPTER I.

WHAT is the object and importance of Geology? Define the term. What is the general opinion respecting the interior state of the earth? How have we arrived at such a conclusion? What are the number of simple bodies? How many of these enter into the composition of rocks? What do you understand by a rock? State their number, and order of succession.

CHAPTER II.

What is granite? State its general position, its character, whether simple, compound, or crystalline. Point out the distinction between it and syenite. Why was the latter so called? What is meant by the term metamorphic? What do you understand by gniess, mica, also of clay slate, and its uses? Can you state the height of the granite ranges? What are glaciers? and where formed? What rivers proceed from them? What are the peculiar products of these ranges? Are gold, precious stones, &c. found here? Under what circumstances? State what they are. What are the subordinate beds? State what you know of the various marbles, serpentine, &c. both ancient and modern. What are their uses?

CHAPTER III.

What is the meaning of the term stratified?—unstratified?—mechanical? The meaning, also, of conformable and unconformable? and group? State how these rocks are formed, and where. What is meant by the term weathering? What is the supposed quantity of mud brought down by the Ganges annually? State other places where these deposits occur. How do these causes affect our own coasts? Are these rocks found lying horizontally, or not? State the angle. What is the cause of difference? State the order of the strata. Are they ever inverted, or not? State the three great divisions in Geology. What is the meaning of paleozoic?—of tertiary, secondary, and primary fossiliferous?

CHAPTER IV.

What is the Silurian system? Why so called? Where found? State its subdivisions—its uses as a building-stone—flagstones—manure, &c. What are its chief, or ruling fossils? Name some of them.

CHAPTER V.

What is Old Red Sandstone? State why called Devonian. State its chief localities—its uses—any marbles found in it—and what? What is the peculiar character of its fossils? By whom first discovered? By whom examined and scientifically described? What is its thickness?

CHAPTER VI.

Why is the system called carboniferous? What are *subdivisions*? What is the nature of limestone? Is

it burnt into lime? Its uses for building, or manure or as a flux? State its importance in these respects. Is it cavernous, or not? Name some of the caverns, and their cause. State some of its localities, and water swallows. What are the usual minerals mined for in it? State its thickness. What is limestone shale? What the character of its springs? What is millstone grit? and why so called? State its uses—quarries—and springs. State its extent, and general character.

What are the coal measures?—their mode of formation? What is coal? State the number and thickness of the beds. On what do they rest?—the under clay?—and its uses? How is the coal obtained? State some of the localities, and its importance and utility to man. What is iron-stone?—and its nature? Is it usually found associated with coal? State, if you can, the importance of this fact. What is its proper flux? Is iron found without coal? and under what circumstances? and where?

What is the Permian system? Why so called? and by whom? State its divisions—the character of the lower New Red Sandstone—its German name. What is the Magnesian Limestone?—its nature?—and extent?—also as a building-stone? State what buildings are constructed with it—its agricultural character.

What is the New Red Sandstone? Why so called? Of what is it constituted as a group? What is Red Marl? What are its subordinates?—gypsum, rock salt?—their character, and uses, and localities?—Its foreign localities?—the difference? What is the Muschel-kalk? State its chief fossils—where found, &c. Are any footprints found in it? Of what animals and birds? What is Lias? State its uses and localities. What are its fossils? Name some of the most remarkable.

What is Oolite? Why so called? Its range and extent? Its use as a building-stone? Agricultural character, and mineral contents? Name some of its chief fossils and fauna.

What is the meaning of the term Wealden? State its subdivisions—its marbles and building-stones. Name some of the buildings constructed of it. What are the character of its fossils, the Iquanodon Pterodactyl, &c.?

What is Chalk? Of what composed? State its range, extent, and foreign localities. Name some of its chief fossils, and their state of preservation. What are its subdivisions? What is green sand? State its relative position to the chalk. What are the character of its fossils?

What does the term Tertiary mean? Why named Pliocene, Miocene, and Eocene? State the peculiarities and fossils in each subdivision. Who first discovered and named those remarkable fossil animals found in the Paris basin? What are Mammalia? Name some of the chief fossils in the London and Hampshire basins, Are they recent, or extinct?

What is the meaning of Drift and erratic blocks? State the cause of transportation. Where are the Magatherium and Mastodon found? What is the meaning of these terms? Name the chief organic remains in the Drift. Are they Drift, or not?

What is meant by recent, or Pleistocene? Name the chief fossils, recent, or otherwise. Are the remains of man found? Under what conditions? And what inference do you draw from this? State any other facts connected with this, &c.

Group of Fossiliferous Strata observed in Western Europe, arranged according to the Descending Series; that is, beginning with the newest, or top measures.

1 Past Pliocene, including those of the Recent, or human period.

TERTIARY, OR SUPRA CRETACEOUS,*

2 Newer Pliocene, or Pleistocene.
3 Older Pliocene.
4 Miocene.
5 Eocene.

SECONDARY, OR MESOZOIC.

6 Chalk.
7 Green Sand.
8 Wealden.
9 Upper Oolite.
10 Middle Oolite.
11 Lower Oolite.
12 Lias.
13 Trias, or New Red Sandstone.

PRIMARY FOSSILIFEROUS, OR PALEOZOIC.

14 Permian.
15 Coal,
16 Millstone Grit, } Carboniferous.
17 Carboniferous Limestone.
18 Old Red Sandstone, or Devonian.
19 Upper Silurian.
20 Lower Silurian.
21 Cambrian, or Older Fossiliferous Strata.

* The late Sir H. De la Beche adopted this term, to designate all the rocks above the chalk. I have followed Sir Charles Lyell in this arrangement, with additions.

AZOIC, (WITHOUT FOSSILS.)

22 Clay Slate including Serpentine and the Primary Marbles, &c.
23 Mica Schist, or Schistose,
24 Gneiss.
} Metamorphic.

25 Syenite,
26 Granite.
} Igneous.

ESTIMATED YIELD OF COAL IN EUROPE AND AMERICA.

	Tons.
Great Britain and Ireland,	64,661,401
Prussia and Germany,	8,000,000
Belgium,	5,500,000
France,	4,400,000
Austria,	2,500,000
Italian States,	90,000
Spain and Portugal,	60,000
Russia,	40,000
Other countries,	50,000
	85,301,401
The United States of America about	6,000,000
Total,	91,301,401

SUMMARY OF THE MINERAL PRODUCE OF THE UNITED KINGDOM IN 1854.

	Quantity.	Value.
Silver,	700,000 oz.	£ 192,500
Iron,	3,069,838 tons.	9,500,000
Copper,	13,042 „	1,229,807
Lead,	64,005 „	1,472,115
Tin,	5,763 „	690,000
Zinc,		16,500
Other metals,		500,000
Coal,	64,661,401 „	14,975,000
Total,		£28,575,922

GLOSSARY.

Abraded: From abrado, Lat. to scrape, scrub, or wear away,—worn by the action of the elements.

Abranchia: From α, priv. and βραγχια, Gr. animals without gills, and having no external organs of respiration.

Acalepha: ακαλη̃φη, a class of zoophites, free-swimmers (not attached to the rock,) found in the waters of the ocean.

Acephalous: From α, *without*, and κεφαλη, *head*, that division of moluscous animals, which, like the oyster and scallop, are without heads.

Acotyledonous: Plants not having cotylodens or seed-lobs.

Acrogens: From ακρος and γενναω. An acrogen is a cylindrical plant, growing at its point only, and never augmenting in thickness when once formed.

Aerolite: From ἀη̃ρ and λιθος, Gr. a name given to meteoric stones.

A'ggregate (Aggrego, Lat.): To collect together, or to accumulate.

Alcyonite: Alcyonites are fossil alcyonia or zoophites, nearly allied to sponges.

Algæ: From Alga, sea-weeds, a cryptogamic class of plants.

Alluvium: Materials transported and deposited by the action of water. (See page)

Alumina: The base of clay. The beautiful precious stone sapphire, is nearly pure alumina.

Aluminous: Clayey.

Ammonite, or *Cornu Ammonis:* So called from a fancied resemblance to the horns engraven on the head of Jupiter Ammon, found at Whitby (Yorkshire,) and locally called snakes-stones; the old legend of St. Hilda, as the legend states, turned the snakes into stone. See Scott's "Marmion," Canto II.

Amorphozoa: α, privative, *morphe*, form. *Zoon*, an animal —shapeless animals, a term applied to sponges, &c.

Amorphous: α, without, and μορφη, form. Bodies not having a regular form, *not* crystalline.

Amphibious: αμφιβιος, an animal that can live either in air or water.

Amphitherium: A mammaliferous quadruped found in the Stonesfield slate.

Amygdaloid: αμυγδαλα, an almond, a variety of trap rock *once porus* or *cellular* like lava, (full of cells,) and subsequently filled in either with carbonate of lime, zeolite, or silex. The usual form of the cells so filled in being *oval*, hence the term.

Anoplotherium: ανοπλος, unarmed, and θηριον, a wild beast. A fossil extinct quadruped resembling a pig.

Anteclinical axis: If a range of hills, or a valley, be composed of strata, which *dip* on the *two sides* in *opposite directions*, the imaginary line that lies *between* them, *towards* which the strata on each side *rise*, is called the anteclinical axis.

Antedilu'vial and *Antedilu'vian:* Ante, before, and diluvium, a deluge; viz. before the deluge.

Anthracite, from *Anthrax:* Coal chiefly composed of carbon, and not bituminous.

Anthracotherium: Gr. ανθραξ, coal, and θηριον, a wild beast, an extinct mammifer, so called from being first found in the anthracite or lignite, (wood coal,) of the tertiary measures near Savone.

Apiocrinite: Pear-shaped encrinite (which see.)

Apteryx: A wingless bird, allied to the ostrich, but smaller.

Archegosaurus: An air-breathing reptile, found in the coal measures.

Arenacious: Sandy; from arena, Lat. sand.

Argil: Clay. *Argillaceous:* Clayey. *Argilla:* Lat. Clay.

Artesian Wells: Springs of water, obtained by boring through strata destitute of water, to the water-bearing strata below them; done first at Artois in France, hence the name.

Articulata: a division of the animal kingdom, from *Articulus*, Lat. a little joint, animals without an internal skeleton with jointed coverings, as insects.

Asaphus: Obscure. The name of a trilobite, the character of which is not well understood.

Asteria: From αστηρ, Gr. a star. The star-fish, or sea-star.

Asterophyllite, from αστηρ, Gr. and φυλλον, A plant found in the coal measures, and so named from the stellated disposition of the leaves around the branches.

Astrea: A genus of corals.

Atoll: A boss of ground, viz. an elevation of the bed of the sea, on which the coral worms construct their reefs in nearly a circular form, with a lagoon inside, a pool of water within the outer edge of the reef, which is always the highest part.—Coral Island, Sir H. de la Beche.

Augite: αυγη, splendour, a compound mineral, chiefly composed of silica, lime, and protoxide of iron.

Augite rock: A rock in which this mineral abounds.

Auvergne: A celebrated ancient (extinct) volcanic district in the South-east of France.

Azoic: Without fossils.

Baculite: (from baculus, Lat.) A straight chambered, conical, elongated, and symmetrical fossil shell.

Bed: Used in Geology to designate a stratum or rock of varying thickness, with *thin partings* of clay, shale, &c. between them. Thus, a hill, or rocky crag, or escarpment, although apparently, at first sight, one solid mass, will be found, on examination, divided into numerous beds, or subdivisions.

Basalt: Said to be derived from an Ethiopian word, *basal,* signifying iron; a heavy, dark green, close-grained trap rock. The Giant's Causeway, Fingal's Cave, &c. are of basalt.

Basset: See out-crop, &c. page 23.

Basin: A depression of strata in which accumulations of more modern date are deposited. Hence we read of the London and Paris basins, the strata of which are deposited in a depression of the chalk.

Batrachia, Batrachian. βατράχος, a frog, Gr. But the term also comprises toads, salamanders, and sirens. The Labyrinthodon is the great fossil toad. (which see.)

Belemnite: (βέλεμνον, a dart, Gr.) Often termed the straight nautilus, (locally, thunderbolts.) An extinct genus of chambered molluscous animals, having a straight, tapering, or conical shell.

Beller'ophon: An extinct cephalapod, or fossil, found in the mountain limestone, shell not chambered.

Bifurcate: Pronged, or forked; divided into two branches, from *bis* and *furca*, Lat.

Bind: Called also clunch. An argillaceous, or clayey ferruginous shale, occurring in thick bands.

Bitumen: Bitumen, Lat. pitch. (Bituminous, impregnated with bitumen, as shale, black marble, &c.) But the term is applied to petroleum mineral tar, asphalt, *elastic* bitumen, &c.

Bluffs: A term used in North America to designate high banks presenting a precipitous front to the sea.

Botryoidal: βοτρυς, grape-like, and εἶδος, form.

Boulders: A provincialism for large rounded blocks of stone lying on the surface, or imbedded in the *soil*, dissimilar in composition to the rocks in their neighbourhood, and were therefore transported from a distance.

Brachiopoda: βραχιων, an arm, and πους, a foot. Animals having arms instead of feet. The term designates a large class of bivalve shells.

Breccia: Breccia, Italian. A rock composed of angular fragments, cemented together by lime, sometimes silex, &c.

Cainozoic: From καινος, cainos, recent; and ζοον, zoon, animal. Recent animals. A term applied to the tertiary rocks.

Calamites: From κάλαμος, Gr. calamus, Lat. a reed, a genus of fossil equisetaceæ. These are characterized by large and simple cylindrical stems, articulated at intervals. They abound in the grits, shales, and connected with the coal-beds.

Calcaire grossier: A series of marine tertiary limestones occurring in the neighbourhood of Paris.

Calcareous: Applied to rocks, spars, &c. of which lime is the *base*; from calx, or calcareous, lime, Lat. Hence *e have* calcareous spar, tufa, &c.

optera: καλεος, a sheath, and πτερον, a wing. An

order of insects, such as beetles, having four wings, the upper pair being crustaceous, and forming a shield.

Cephalaspis: Buckler-headed; a sauroid fish from the Old red sandstone.

Carapace: The upper shell of reptiles.

Carbon: The elementary constituent, or real substance of charcoal and the diamond, of the latter specially.

Carboniferous: A term applied to the mountain limestone, as it is usually coal bearing, viz., associated with the coal-beds; as carbo, coal; and fero, to bear.

Caryophyllia: A coral zoophite.

Cataclysm: κατακλυζω, to deluge.

Cotyledon, Cotyledonous: From κοτυληδων, Gr. the side-lob, or seed-lob of seeds. The palms, the tulip, lily, &c. are cotyledonous.

Caudal: Belonging to the tail.

Cephalopod:

Cephalopoda: From κεφαλή, head, and ποδα, a foot. Applied by Cuvier to a large family of molluscous animals, (Nautili and ammonites,) from having the feet placed around their heads, and walking with their heads downwards.

Cestracion, Cestracionts: An extinct family of sharks, of which only one type exists at present, the Port Jackson shark.

Cetacea: An order of vertebrated mammalia inhabiting the sea—"cete," whales, dolphines, &c.

Chelonia, Chelonian: From χελωνη, testudo, the tortoise tribe. In the arrangement of Cuvier, chelonia forms the first order of reptilia, (reptiles.)

Chert: A siliceous, or flinty mineral, (flinty slate,) often interstratified with the carboniferous limestone; in which case they are called the chert measures.

Chirotherium: χειρ, a hand, and θηριον, a wild beast. An extinct animal, which has left impressions of foot-prints like those of a toad, on sandstone, (New Red.) The gigantic Labyrinthodon is one of the species.

Cidaris: Cidaris, Lat. A family of fossil echinites. The *recent* ones are called sea-urchins, and sea-hedgehogs, from being covered with spines.

Congeners: Species which belong to the same genus.

Conglomerate, or *Pudding-stone:* Rounded water-worn, fragments, or pebbles, consisting of various kinds of stony matter cemented together, either by siliceous, calcareous, or argillaceous matter.

Coniferæ: From conus, a cone, and fero, Lat. to bear, (trees bearing cones.) An order of plants which, like the fir and pine, bear cones, or tops, in which the seeds are contained.

Coomb: Very narrow steep valleys traversing the chalk downs in the South of England.

Coprolite: The petrified fæcal matter of carnivorous reptiles.

Coral, Corallines: From κοράλλιον, Gr. Corallium, Lat. Coral is the production (stoney-houses, or cells,) of a variety of polypi, belonging to the class zoophite. The different species, which construct the magnificent coral banks or reefs, are the genera, meandrina, caryophyllia, millepora, and astrea, especially the latter. Coral is composed of carbonate of lime, which these wonderful creatures, like the shell fish, have the power of eliminating from the simple elements of matter.

Cornbrash: An extensive corn-bearing district belonging to the Oolite, chiefly in Wiltshire. Brash is derived from *brecan*, Saxon, to break.

Cosmogony: From κοσμος, the world, and γονη, generation. This is applied to speculations respecting the first origin of the earth.

Cretaceous: From creta, Lat. chalk—belonging to chalk.

Crinoidea, Crinoidean: From κρινον, and εἰδος, Gr. Lily-shaped zoophites, or stone-lilies; a name given to the class of Encrenites and Pentacrinites, from their resemblance to the head of the lily.

Crop-out: Signifying the emergence of a stratum on the surface, often called outcrop of the measures. A miner's term.

Crustacea, Crustacean: Animals which have a hard, shelly coating, or crust, which they cast annually, such as [illegible]bs, lobsters, shrimps, &c.

[illegible]*gamic, or Cryptagamia:* From κρυπτος, concealed, γαμος, marriage. A name applied to a class of [illegible]ts, such as ferns, mosses, &c. in which the organs of [illegible]duction are concealed.

Ctenoidian: From κτεὶς, a comb, and εἶδος, Gr. The third order of fishes in the arrangement of M. Agassiz.

Cycad, Cycadea: From κυκας, cycas, Gr. The cycadea hold an intermediate place between the palms, ferns, and conifers.

Cycas, Cycadeæ: From κυκας, Gr. cycas. An order of plants mostly tropical. A name given by the ancients to the palm.

Cycloïdeans: From κυκλος, Gr. The fourth order of fishes. —M. Agassiz.

Cystideæ: A variety of radiated animals, having spheroidal bodies covered with polyganol plates, with a mouth on the upper side, and a point of attachment for a stem, intermediate between crinoids, and echinoderms. Found in the Silurian Rocks.—Sir C. Lyell, Elements, 4th Ed. page 358.

Debacle: From *Debacle*, or Debacler, Fr. to unbar. A violent torrent, or rush of waters; to break up, as a river does at the end of a long frost.

Debris: The ruins of strata; abraded and water-worn fragments of rocks, as silt, sand, rubbish, &c. brought down by torrents, or the action of water generally.

Degredation: The wearing away of rocks, generally effected by aqueous action.

Delta: Alluvial deposits formed at the mouths of rivers, which are often triangular in shape, as in the Nile, by the stream being divided. Hence the name of the Greek letter Δ is used to express it.

Denudation: From Denudo, to lay bare. The upper part, or the entire, of many rocks are carried away by the action of water, and the inferior rocks beneath them are laid bare. Hence the latter are said to be denuded.

Dermal: From δερμα, Gr. belonging to the skin.

Desiccation: From Desicco, Lat. to dry up. Like the ground, which becomes dried and cracked in hot weather; and rocks also become *weathered*, and crack, by exposure to heat and cold.

Detritus: Lat. The worn off, or rubbed off materials of rocks.

Diatomaceæ: From δια and τομος. The supposed microscopic broken-up joints of algæ, or plants.

Dicotyledonous: From δις, double, and κοτυλεδων.

grand division of the vegetable kingdom, applied to plants having two cotyledons, or seed-lobes.

Didelphys: From δις, and δελφύς, having two wombs. A marsupial animal, allied to the opossum and kangaroo.

Dike, or Dyke: A Saxon term, dic, or dyk, used in the north of England and Scotland for a wall, or embankment. In Geology, it is applied to a mass of igneous rock, as granite, trap, or lava, injected into a great rent of the stratified, or other rocks, and cutting across the strata like a wall. One in North Yorkshire and Durham is 90 miles in length.

Diluvial, Diluvian: From Diluvium, Deluge. Applied by Dr. Buckland to all those accumulations of clay, sand, and gravel, which he considered were the results of the Noachian Deluge.

Dinornis: A fearfully great bird. Applied to some enormous bird, perhaps like the Dodo, the skeleton of one of which was found by Mr. Mantell in New Zealand. Footprints of some such bird have been found, of great size in the new red sandstone, Connecticut, U. S.

Dinosauria, Dinosaurians: Fearfully great lizards.

Dinotherium: From δινος, and θηριον, Gr. Meaning a formidable wild beast—an extinct mammifer.

Diptera: From δις and πτερου, Gr. Two winged insects.

Dislocation: From dis and locus, a place, Lat. Used in Geology in reference to strata which is broken up and *displaced* by volcanic, or other agency.

Disruption, or *Dislocation:* A forcible rending asunder.

Dolomite: Magnesian limestone.

Dorsal: From dorsum, the back, Lat. Appertaining to the back. Dorsal fin, the fin of a fish, on the back, &c.

Dunes: Low hills of blown sand, that skirt the shores of Scotland, Holland, France, &c.

Echinodermata, Echinoderms: From εχινος, sea-urchin, or egg; and δερμα, hard skin, or hedgehog-skinned animals. An order of radiated animals, including echinus, or sea-urchin; astrea, or star-fish, &c.

Edentata: The sixth order of mammalia in Cuvier's arrangement, or quadrupeds without front teeth.

Elvan: A Cornish term for granitic porphyry, which, in the form of dykes, cuts through the strata.

Embouchure: The mouth of a great river.

Enalio-saurus: From ἐναλιος, enalios, marine, and saurus, a lizard. A name applied to extinct fossil reptiles, such as the Ichthyosaurus, &c.

Encrinite: From ἐν, and κρινον, (Lilium.) A genus of lily-shaped animals, *of the order crinoïdea*, called stone-lilies.

Entrochite: From ἐν, and τροχος, a wheel. A name given to the broken stems of fossil encrinites, millions of which are found in the Derbyshire grey marble, called entrochal marble, and the cherts.

Eocene: From ἠως, the *dawn*, and καινος, recent. The commencement or dawn of the present race of living things.

Ephemeron: Creature of a day.

Epoch: A fixed point in time. It also means a period.

Equisetaceæ: From equisetum, Lat. horse-tail. Cryptogamic plants.

Eroded, Erosion: Worn away, or the wearing away of an exposed rock.

Erratic, Erraticus: From erro, Lat. wandering, not fixed, irregular. The term is applied to multitudes of rounded, or water-worn blocks of stone, some of vast size, strewed over the plains of Europe and parts of England, which have been transported from distant localities on blocks of ice at some distant era. They chiefly consist of granites, greenstones, &c. The author has a piece of one found in Derbyshire containing garnets.

Escarpment: The abrupt face, or steep side of a ridge of high land.

Estuary: From æstuo, to rise and fall. An inlet of the land entered both by rivers and tides of the ocean, as the estuaries of the Humber, Mersey, Thames, &c.

Exogens, Exo'genous: From ἐξω, and γενναω. Plants in which the growth takes place by additions from without, or by external increase.

Exotic: Foreign; as exotic, or foreign plants, &c.

Exuviæ: Lat. Applied to the organic or fossil remains found in the strata. Properly, it means cast shells, or cast skins.

Falun: A provincial name given to some shelly limestone

in Tourraine, (France,) which resemble, in lithological characters, the crag of Suffolk and Norfolk.

Fault: "In the language of the miners, is the sudden interruption of the continuity of the strata in the same place, accompanied by a crack, or fissure, of varying width, from a mere line, to several feet, and generally filled in with broken stone, clay, &c.—See Cat.

Fauna: "As the plants peculiar to a country constitute its *flora*, so do the animals constitute its fauna." It is thus applied to all the organic remains found in the strata.

Ferruginous: From ferruginous, or ferrum, rusty iron, Lat. Applied to anything containing iron, which generally gives it a reddish tinge.

Fiord, or *Fjord:* A deep, narrow inlet from the sea; a word used in Sweden and Norway.

Fire-clay: The under clay of the coal is often thus called, because it resists fusion at a very high temperature.

Fire-damp: Carburetted hydrogen gas evolved from coal in mines, which becomes explosive by mixture with common air. Hence the terrible explosions which often occur in coal mines.

Fire-stone: A stone that resists fusion at ordinary high temperature. The upper green sand deposits are often used for such purposes, and are so called.

Fissile: From fissilis, Lat. To be easily cleft, or divided, into thin layers, as roofing-slate, mica, &c. &c.

Fissure: From fissura, Lat. A cleft, or narrow chasm.

Flint: A term applied to those siliceous bodies distributed through the chalk, having been once sponges, &c.

Flora: "The various kinds of trees and plants of any country constitute the flora of that country in the language of botanists."

Fluvial, Fluviatile: From fluvius, Lat. A river; belonging to a river, as fresh-water fish, shells, &c.

Flux: A substance added to render certain minerals more fusible; as an instance, limestone is used in the blast furnaces to assist in the fusion of the ironstone.

Fora'men, Lat. Forami'niferous: A hole, or opening; *pierced with small* openings. A term applied to a class of animalcules having perforated shells.

Formation: A group of deposits, of whatever kind, belonging to the same period, or having one common origin.

Fossiliferous: A term applied to all rocks containing shells, or other organic remains.

Fossils: From fossilis, Lat. That which is dug out of the earth, usually applied to such bodies as have been once animals or plants.

Free-stone: Applied to most, or all, of the sandstone rocks, from their being *hewn*, or cut *freely* in any direction.

Fucoid, Fucoids: From φῦκος, and εἶδος. A species of fucus; (fuci plural;) a genus of the order algæ; seaweeds.

Fusiform: Spindle-shaped.

Galena: From galena, to shine, Lat. A sulphuret of lead; foliated lead ore, called so from the extreme brilliancy of the fracture.

Gallinaceæ: The gallinæ of Linnæus. Fourth order of the second class of Aves, birds.

Gánoid, Ganoídians: From γανος, Gr. splendour. The second order of fishes—M. Agassiz—called so from the splendour of their enamelled scales.

Gasteropoda, Gasterapods: From γαστηρ, the belly, and πους, or ποδα, the foot. The third class of molluscous animals, in which, as in the limpet, the foot is attached to the body.

Gault: A provincial name given to a series of beds of clay and marl in the South-east of England, *lying between* the upper and lower green sand.

Gávial: A name given to the crocodiles of the Ganges with long snouts.

Genus, Genera: A group of species having certain important characters in common, whether animal, vegetable, or mineral.

Ge'ode: γεώδης, earthy, from γεα, Gr. A roundish piece of rough-looking stone, which, when broken, is often found to be lined inside with bright crystals of quartz, (the *potato* stone of Bristol,) and sometimes with earthy matter. The term is likewise applied to small cavities in rocks lined with crystals of dog-tooth, and other spars, (calcareous, &c.)

Geognostic: From γῆ, the earth, and γινώσκω, to know. A term sometimes applied in geology. See below.

Geology: From γῆ, the earth, and λόγος, a discourse. To speak of the earth.

Geosaurus: (Cuvier.) A fossil saurion, or reptile, of the Oolite and lias formations.

Glacier, Glaciers: From *glace*, French for ice. Vast accumulations of ice and snow on all lofty mountains, as on the Alps, Mount Ararat, &c.

Gneiss: Laminated granite. See page 15.

Goaf: A mining term applied to all that erea from which the coal has been extracted, which often proves dangerous from the collection of the fire-damp in it.

Gra'llæ: Gra'llæ, Lat. stilts, or long legs. An order of aquatic birds called waders, living in swamps and marshy ground, as the stork, bittern, &c.

Gramina, Gramineæ: From gramen, Lat. grass, grasses. The fourth order in Linnæus's division of plants.

Granular: Consisting of small grains.

Graphite: Black lead, or plumbago, a carburet of iron.

Graptolite, Graptolites: A fossil zoophite found in the Silurian shales.

Grauwacke, or *Greywacke:* A German term for one of the older fossiliferous rocks of a grey colour.

Grit: A provincial term for a coarse siliceous sandstone. Hence we have the millstone grit of this kind, so called because quarried for millstones.

Gypsum: From γύψος, Gr. *gypsum*, Lat. A sulphuret of lime, (lime and sulphuric acid,) which forms an extensive bed in the marl of the new red sandstone, and is quarried *extensively, and burnt*, to make plaster of Paris; the best and finest being also manufactured into ornaments in Derbyshire, &c. Italian alabaster is a compact variety of gypsum.

Gyrodus: Thick-toothed. A fossil fish of the family of the Pycnodonts.

Hamite: From hamus, Lat. a hook. A genus of many chambered (multi-locular) fossil shells, in the form of *a hook, or hook*-formed; from the gault.

Hemiptera: From ἥμισυ, and πτέρον. So called because their *wing* covers at the base are coriaceous, resembling *horn, or leather*, and at the tip are membraneous.

Herbivorous: From herba, an herb, and voro, Lat. to devour, or feed upon.

Heterocercal: A name applied to fishes which have their tails unequally bilobate, (divided,) like the shark and sturgeon, the vertebral column running along the upper caudal lobe.

Holoptychus: A saurian fish, 2 feet 4 inches long.

Homocercal: A name given to fishes, the termination of whose tails is equally divided, as the herring, &c.

Hornblend, Hornblend rock: A compound mineral, composed chiefly of silica, lime, magnesia, alumina, and protoxide of iron; which enters largely into the composition of some rocks, as syenite, green-stone, basalt, and other igneous rocks.

Hybodus, Hy'bodonts: From ὑβὸς, Gr. and dens, Lat. The fishes of another extinct family of sharks, termed hybodus, from the gibbous form of the teeth.—Doctor Mantell Medals, page 609.

Hydrophytes: From ὑδωρ, water, and φυτον, a plant. Plants which grow in water.

Hylæosau'rus: Wealden lizard, a gigantic extinct saurian, about 25 feet long, discovered by Dr. Mantell.

Hymeno'ptera: From υμενόπτερος, membraneous wings. The ninth order of the class insecta.

Hyotherium: An extinct animal, allied to the tapir, found in the miocene strata.

Hypogene: From ὑπο, under, and γινομαι, to be, or to be born. A word implying the theory that granite, gneiss, and other crystalline formations, are *alike* netherformed rocks; that is, formed under the surface.—Lyell, Elements, page 9.

Hyracotherium: A variety of mammal found in the London clay. (Lyell, Ed. p. 203.)

Iceberg: From *ice* and *berg*, German for hill. Great masses of ice, some of which have been observed 300 feet *high*, and supposing only an equal thickness to exist unseen beneath the water. This would be equal to 600 feet in thickness; but it is known that for every *foot above*, there are 8 *feet* beneath. Such are the enormous masses that float in the Polar and Northern Seas. They have been, and are often now, the means

of transporting to great distances animals, plants, and masses of rocks.

Ichnolithes: Footprints on stone.

Ichthyology: ἰχθὺς, a fish, and λογος, discourse. The study and description of fishes.

Ichthyosaurus: From ἰχθυς, fish, and σαυρα, lizard. A fish-like lizard; a gigantic fossil reptile between a fish and lizard.

Ichthyodorulites, Icthyodorulite: Fossil spines. From ἰχθυς, fish, δορος, a spear, and λιθος, a stone. Dorsal spines of fish, forming their defensive armour. Hence the name. They belong to an extinct class of cartilagenous fish.

Igneous: Igneus, Lat. fiery. Applied to all rocks that have been *produced, fused,* or affected by intense heat, such as granite, basalts, and lavas.

Imbricated: From imbricatus, Lat. Laid one over the other at the edges, like tiles on a house.

Impermeable: Not admitting water to pass through, as clay, &c.

Incande'scence, Incande'scent: From incandesco, Lat. To be very hot; (white hot;) having, by far, a more intense heat than red heat.

Indurated: Hardened.

Indusiæ: From indusia, Lat. The case, or covering, of the larvæ of phryganea, vast numbers of which have been incrusted or imbedded in lime. Hence called by Sir J. Lyell Indusial limestone, a fresh water formation of Anvergne in France.

Infusoria: Microscopic animalcules, generated in all infusions, some of them possessed of siliceous coverings, or shields, but are so minute, that in one *line* of a *cubic inch* of the polierschiefer (polishing slate) of Bilin there are no less than 80,000,000. They are found both in marine and fresh water.

Insecti'vorous: From insectivora. Animals subsisting wholly, or in part, on insects.

Inspi'ssated: From in and spissatus. Thickened by being *dried up.*

Invertebrata, Invertebrated: Animals without a back-bone, as the mollusca, articulata, &c. &c.

Iguanodon: Called so by the late Dr. Mantell, as he

states, "Signifying an animal having teeth like the 'modern' Iquano." An extinct colossal lizard, about 40 feet long, modelled in the Crystal Palace grounds.

Kao'lin: The Chinese name for porcelain earth, or clay, of which they made their chinaware. It is chiefly decomposed feldspar.

Killas: A provincial term for a coarse argillaceous schist; a variety of slate; a coarse slate.

Kimmeridge clay: A thick bed of bluish clay belonging to the oolitic group found near a town of that name in the Isle of Purbeck, as *Oxford* clay, &c.

Labyrinth: From λαβύρινθος. A name given to cavities having numerous windings and intricacies.

Labyrinthodon: From labyrinthus, Lat. λαβύρινθος, and ὀδούς, Gr. a tooth. A tooth; a gigantic toad, or frog, 13 feet long, of the order batrachia, discovered in the Trias or new red sandstone near Warwick, and named by Professor Owen from the vast and almost untraceable foldings in a slice of the tooth when cut. It is now discovered that the chirotherium and this enormous creature are one and the same. The labyrinthodon is modelled and placed in the grounds of the Crystal Palace.

Lacerta: Lat. a lizard; Lacertinidæ, lizards. Order sauria.

Lacustrine: Belonging to a lake. All deposits taking place in them are called lacustrine deposits.

Lagoo'n: From *laguna*, Ital. A salt water lake; often formed within coral reefs.

Lamaller, Lamelliferous: From lamella, a small plate, and fero, to bear. Composed of thin plates, or leaves, like paper. Having a structure consisting of thin plates.

Lamina, Laminated: A thin plate, or scale; applied, in geology, to thin layers, of which the stratum is frequently composed.

Lapidification: From lapis, a stone, and fio, to make, or become; viz. conversion into stone.

Lapilli: From lapillus. Small volcanic cinders, or ashes, abounding in minute globular concretions.

Larva: The first stage of an insect.

Lava: The matter which flows in a melted state from volcanoes during eruptions. It hardens into stone. It is of various colours.

Lepidodendron: From λεπις, and δενδρον, Gr. (scaly tree.) An extinct genus of fossil plants frequently found in the coal beds.

Lepidoptera: From λεπις, a scale, and πτερον, a wing. Insects having scaly wings, as moths, &c.

Lias: Corrupted from the word *layers*, which designates a peculiar bluish and drab-coloured limestone, or loam. The base of the oolitic group, and remarkable for its fossils, ichthyosaurus, shells, &c. &c.

Ligneous: From *ligneus*, Lat. Resembling wood; as having a ligneous structure, &c.

Lignite: From lignum, Lat. Wood partially converted into coal.

Line: Used in the measurement of crystals. A *line* is one-tenth of an inch.

Lingula: A little tongue, a genus of shells.

Lithodomus, Lithodomi: From λιθος, a stone, and δεμω, to build. Molluscous animals, which bore holes in solid rocks, as their place of abode. It seems they have the chemical power of dissolving the rock.

Lithological: A term used to denote the stony character of mineral masses.

Lithophagi: From λιθος, a stone, and φαγειν, to eat. Molluscs which eat or wear holes in stones and solid rocks by abrasion, not chemically, like the lithodomi.

Lithophytes: Stone-plants; a term applied to corals, from λιθος, a stone, and φυτον, a plant.

Littoral: From littus, Lat. The shore; belonging to the shore.

Loam: A mixture of sand and clay.

Lode: A mass of metal found together, occurring in metallic veins, is so called, in contradistinction to the usual fact of its being found running from a fine thread, or threads, in thickness, to several inches, pretty uniformly throughout the vein.

[illegible]: *A genus* of the Sepiæ, allied to the common *cuttle-fish, and* containing an ink bag.

[illegible]don: From λοφις, and οδους, Gr. A genus of ex-

tinct quadrupeds allied to the tapir; named from eminences on the teeth.

Lycopodia'cea: Plants of an inferior degree of organisation to coniferæ, some of which they greatly resemble in their foliage. The club mosses, &c.

Lymnæa, Limnea: From λιμνας, Gr. A genus of fresh-water bivalve shells.

Macacus: A British extinct fossil monkey, found in the Eocene strata.

Maci'gno: An Italian word for a kind of siliceous sandstone sometimes containing calcareous grains.

Macrauchenia: From makros, long, and αυχην, neck. An extinct animal resembling the Llama.

Macropoma: A genus of sauroid fishes found in the chalk.

Macropus: Kangaroo.

Madrepore: A genus of corals. The term madrepore is generally applied to all those corals which have superficial *star*-shaped cavities.

Madreporite: Applied to limestones containing madrepores.

Magilus: A genus of univalve shells.

Magnesia: One of the earths. *Magnesian limestone* (lime and magnesia) is called so from its containing about 40 per cent of magnesia; and this forms an extensive series of beds immediately above the coal beds, which, with its associated sandstones, is called by Sir R. Murchison the Permian System. Which see.

Malleable: Capable of being beaten out into bars, thin plates, or drawn out into wires, &c.

Mammália, Mammifera: From mammæ, Lat. the breast. Animals which give suck to their young. To this class all the warm-blooded quadrupeds belong, and also the Cetacea, or whales, &c.

Mammali'ferous: From mammalia and fero, to bear, or produce. Applied to those strata which contain the remains of mammifers. The upper Tertiaries.

Mammillary, Mammillated: A surface which is studded over with rounded or pap-like projections.

Mammoth: An extinct species of Elephant. Elephas primigenius, or primitive elephant.

Mandibles: Jaws.

Mantle: This term is applied to the soft external envelope of molluscous animals.

Marl: A mixture of clay and lime, usually soft. When hard, it is called *compact* marl. The *red* Marl is an extensive formation belonging to the Trias group.

Marsupial: From marsupium, a purse. A name given to animals having an abdominal sack, or pouch, as the kangaroo, &c.

Marsupite: A zoophite, allied to the crinoidea, found in the chalk.

Mastodon: From μαστὸς, a breast, or pap; and ὀδους, a tooth. A genus of fossil extinct quadrupeds allied to the Elephant, the name being derived from its having *tuberculated teeth*.

Matrix: Womb. A term applied in mineralogy to a mass, or substance, in which a crystal, or any mineral body, or fossil, is embedded.

Mechanical: applied to sedimentary deposits, as contradistinguished from the igneous rocks.

Medullary: applied to the central pith of plants, and the vertebral canal of animals.

Medusæ: A genus of marine radiated animals without shells.

Megalichthys: From μὶγας, great, and ἰχθυς, a fish. A gigantic sauroid fish found in the Carboniferous strata of Burdie-House, N. B.

Megalonyx: From μεγας, megas, great, ονυξ, onyx, a claw. A huge fossil mammalian, of the order of Edentata, found in the coal beds near Edinburgh.

Megalosaurus: From μὶγας, great; and σαυρος, a lizard. A fossil, gigantic, amphibious saurian, or lizard, found in the oolitic limestone of Stonefield, from 30 to 40 feet long.

Megatherium: From μεγας, great, θηριον, wild beast. An extinct colossal quadruped allied to the Sloth, found in the Pampas of South America. Its clawed feet were one yard long, haunches five wide, and its body twelve *feet* long, and eight feet high. It is presumed that it *lived upon roots* of all kinds.

Mesozoic: From μεσος, mesos, middle, and zo-on, an animal. A term used to designate all that group of

rocks, called secondary, forming the great middle fossiliferous group.

Metacarpal: From μετα, with, and καρπὸς, the wrist. Belonging to the metacarpus, as the metacarpal bones, &c.

Metalliferous: From metallum, metal, and fero, to produce. Applied to rocks containing metallic ore. Hence metalliferous strata, beds, &c.

Metamorphic: From μετὰ, trans, and μορφη, form. This term is applied to all rocks which are changed by heat. Hence metamorphic rocks, clay-slates, &c. See p. 15.

Metatarsus: From μετα, and ταρσὸς. That part of the foot which lies between the ancle and toes; metatarsal bones, &c.

Mica: From mico, to shine, or glisten, Lat. A constituent of granite, very flexible, and easily split, or divided, into the thinnest possible laminæ. It is a compound of potash, silica, alumina, magnesia, oxide of iron, &c. *The brilliant* particles in granite are mica.

Mica slate, and Micaceous schists: One of the lowest stratified rocks belonging to the primary class; chiefly composed of mica and quartz.

Micaceous: Stratified rocks, sandstones, &c. which contain mica.

Millstone grit: The name given to a coarse sandstone used for millstones, and forming the base of the coal measures generally.

Miocene: From μειὼν, less, and καινος, recent. A term applied to the middle tertiary strata.

Molasse: From mollis, soft. A provincial name for a soft green sandstone belonging to the miocene period, and extensively developed in Switzerland.

Molecules: The ultimate particles, or atoms of bodies, viz. very minute.

Mollusca: From *mollusca*, a nut with a soft shell, or mollis, soft. A term applied to animals, such as shell-fish, having soft bodies, and devoid of bones.

Mo'nad: From μονας, unit. The minutest infusorial animalcules.

Monitor: An animal of the saurian or lizard tribe, species of which are both found fossil and recent. The recent inhabit the tropics.

Monocotyle'don, Monocotyledonous: From μονος, one, a κοτυληδων, a seed-lobe. A grand division of the ve table kingdom, including palms, grasses, &c. havi only one seed-lobe.

Mora'ine: An accumulation of debris (stones, & formed in Alpine valleys by glaciers; often fou accumulated on glaciers and icebergs.

Mososaurus: An aquatic reptile, about twenty-five f long, holding an intermediate place between the Mo tors and Iquanas, with webbed feet.—Mantell.

Mountain limestone: The carboniferous limestone occurri immediately below the coal measures.

Moya: A South American term for mud poured out volcanos during eruptions.

Multilocular: From multus, and loculus, Lat. Ma chambered, as the Nautilis and Ammonite.

Multivalve: Shells composed of many pieces, as t chiton.

Murex: A univalve shell, from which the ancients p duced the purple dye. A genus of shells (recent) fou chiefly in the Mediterranean.

Muschelkalk: A shaly limestone belonging to the Trias group, found in Germany, but wanting in these m sures in England; derived from muschel, shell, a kalkstien, limestone.

Mylodon: A gigantic Edental animal allied to the Slo Length, about eleven feet; girth round the thick part of the trunk, nine feet nine inches. Sou American.

Naphtha: ναφθα, Gr. *naptha*, Lat. A mineral oil, v volatile, and highly inflammable. Springs of it ex on the shores of the Caspian Sea, and elsewhere.

Neptunian: This term is applied to Werner's system Geology, who supposed that all the rocks were form by the agency of water alone.

New Red Sandstone: A series of sandy, argillace strata. See p. 94.

Nodule: A rounded irregular-shaped mass of rock form *by abrasion*; from the Latin, *nodus*, a knot.

Nucleus: A solid central piece, round which matter ...llected; from the Lat. *nucleus*, a kernel.

Nummulites: From nummus, Lat. for *money*, (like money,) and λιθος, lithos, stone. A group of Foraminiferous shells, an extinct genus of the Order of molluscous animals called Cephalopoda. Some of the pyramids of Egypt are formed of nummulite limestone. These rocks belong to the oldest tertiary period.

Oasis: A fertile spot in a desert.

Obsidian: A volcanic product, called volcanic glass, or vitreous lava, precisely like black bottle-glass, found at Vesuvius, &c.

Ochre, Ochreous: From ωχρα, Gr. ochra, Lat. An oxide of iron, both red and yellow in colour. When prepared, it is used as a pigment.

Old Red Sandstone: The base of the carboniferous limestone, &c. See p. 37.

Onchus: A genus of sharks, belonging to the sub-family of Hybodonts, teeth of which have been found in the lias of Lyme Regis.

Oolite, and *Oolitic*: A limestone, so termed because constituted of an aggregation of minute globules; from ωον, oon, an egg; and λιθος, stone. See pp. 103 and 108.

Ophidious Reptiles: From οφις, ophis, a serpent. Vertebrated animals, such as snakes and serpents.

Ophite: From οφις, a serpent. A green porphyry, not unlike serpentine, but containing crystals of felspar. The Ophite of Pliny.

Organic remains: A term applied to all fossil bodies having a regular organized structure.

Orthoce'rata, Orthoceratite: From ορθος, orthos, straight; and κερας, keras, a horn. "An extinct genus of the Order of molluscous animals called cephalopoda, which inhabited a long-chambered, conical shell, like a straight horn;" found in the carboniferous limestone.

Out-crop: The line at which a stratum shows itself at the surface.

Out-lier: An *isolated* hill, or one detached from the main chain, or group.

Ovate: From ovum, egg; egg-shaped.

Oxide: The combination of a metal with oxygen. The rust of iron is an oxide.

Pachydarmata: From παχυς, pachus, thick, δερμα, skin,

thick skinned. An order of quadrupeds, such as the elephant, rhinoceros, horse, pig, &c.

Palæothorium: From παλαιος, palaios, ancient; and θηριον, a wild beast. An extinct genus of fossil quadrupeds, belonging to the order pachydarmata, and allied to the tapirs.

Paleontology: From παλαιος, palaios, ancient, οντα, onta, beings, and λογος, a discourse. The science which treats of fossil bodies, both animal and vegetable.

Pampas: Treeless plains of Patagonia, in South America.

Paper-coal: A variety of bituminous shale, capable of being split into very thin leaves.

Peat: Vegetable matter, accumulated in moist situations, and converted into a spongy mass. Hence peat-bogs, &c.

Pelagian, Pelagic: From Pelagus, Lat. for sea. Belonging to the sea. Sir C. Lyell adds *deep* sea.

Pentacrinite: From πεντε, five, and encrinite. So called from the pentagonal form of its vertebral column. The fossil pentacrinite.

Peperino: An Italian name for a variety of volcanic rock formed of volcanic sand, cinders, &c. cemented together.

Petroleum: From petra, Lat. for rock, and oleum, oil. Mineral pitch in a fluid state. It oozes from the rock like oil. Hence the name.

Phœnogamous, or *Phanerogamic plants*: From φανερος, phaneros, evident; and γαμος, marriage. Plants in which the reproductive organs are apparent.

Phascolotherium: An extinct animal, allied to the marsupeds, or kangaroos of Australia.

Phonalite: From φωνη, sound, and λιθος, a stone. Another name for clink-stone; any stone that is *sonorous* when struck with a hammer.

Physics: From φυσις, physis, nature. That branch of science which treats of the properties of natural bodies, including natural history and philosophy.

Pisolite: From πισον, a pea, and λιθος, a stone. A stone *made up* of rounded concretions like peas; globular masses agglutinated together, from the Oolite.

Pit-coal: Ordinary coal, so called because it is obtained *by sinking pits* to procure it.

Placoid, Placoidian: From πλαξ, a broad plate, and εἶδος, form. A group of fishes, so called from the structure of their scales.

Plastic: Capable of being moulded into form. All clays used in pottery are called plastic clays.

Pleocene: From πλειων, pleion, major; and καινος, recent. Meaning that the major part of the fossil shells found in the upper tertiaries are recent, or similar to those existing in our present seas.

Plesiosaurus: From πλησιον, plesion, near to; and σαυρα, saura, lizard. A genus of extinct amphibious animals, "resembling the saurian, or lizard and crocodile tribe."

Plicated: Arranged in folds or contortions.

Plutonic Rocks: All the igneous rocks are thus called, as granite, basalt, &c. because they are supposed to have been consolidated from melted matter at a great depth beneath the surface.

Poikilitic: From ποικιλος, variegated. A term applied to to the new red sandstone from its variety of colours.

Polyparia, Polypi: Corals. The fourth class of the radiata, or zoophites, so called from a supposed resemblance to an octopus, called polypus by the ancients.

Polythalamous: From πολυς, many, and θαλαμος, a chamber. Having many cells, or chambers, as the nautilus ammonite, &c.

Porphyry: From πορφυρα, porphyra, purple. An igneous rock of a red colour, containing small whitish crystals of felspar, found in Egypt, and much prized by the ancients.

Pozzuolana: Volcanic ashes, which is used as a mortar, in Italy, for buildings, and similar to the Roman cement. It is shipped at Puzzuoli, a town in the bay of Naples. Hence the name.

Prairies: A term applied to the level plains of some of the great river valleys of North America.

Precipitate: The chemical deposit of a substance held in solution by water.

Primary, or *Primitive*: A term applied to rocks destitute of fossil remains, and that *underlie* the mechanical rocks which contain them.

Pterodactyl: From πτερον, a wing, and δακτυλος, a finger,

wing-footed. An extinct genus of winged reptiles; found throughout the secondary rocks.

Pumice: (From pumex, Lat. the name of a stone.) A light, spongy lava, (pumice of commerce.) Sir C. Lyell says it may be called the froth of melted volcanic glass.

Pycnodonts: From πυκνος, thick, and ὀδους, a tooth. Thick toothed fishes; an extinct family of fishes.

Quadrumana: From quadrus, a Latin term for the number four, and *manus*, hand. The second order of mammalia, including the monkeys, lemurs, &c. the fore-feet of these animals being, in some measure, usable as hands.

Qua-qua, versal *Dip*: The dip of beds in every direction from an elevated point. "The beds on the flanks of a volcanic cone dip in this way."

Quartz: A German name for silex. Rock crystal and flint are examples of this.

Radiata: The name given to the fourth great division of the animal kingdom, "so called because the body is often presented in a radiated form, like the star-fish."

Ramose: From ramus, Lat. a branch. Branched.

Ravine: A narrow excavation, formed by the force of running water.

Recent: This term is applied to the newest order of things on the earth connected with the introduction of the human race.

Red Marl: A name given to the upper members of the new red sandstone.

Reliquiæ: Remnants: remains of the dead: applied to all fossil organisms.

Reniform: Kidney-shaped.

Reticulated: A structure of crossed lines, or fibres, like a net, is said to be reticulated.

Rodentia: From rodo, to gnaw, Lat. (gnawers.) An order of animals with peculiar teeth as the rabbit, hare, squirrel, &c.

Roe-stone: The name often given to Oolite.

Rothe Todte liegende: The German name given to the lower new red sandstone belonging to the Permian [illegible].

Ruminantia, Ruminants: From rumino, Lat. Animals which ruminate or chew the cud, as the ox, deer, &c.

Saccharoid, Saccharine: From σακχαρ, sacchar, sugar; and ειδος, eidos, form. A term given to the white statuary marble, because it is, when broken, so like loaf-sugar.

Saliferous system: The new red sandstone series, so called from its containing beds of rock-salt, as found in Cheshire, and elsewhere.

Saurian: From σαυρα, saura, a lizard. Any animal belonging to the lizard tribe.

Savannahs: The low plains of North America, generally covered with wood.

Schist: From schistus, Lat. Implying the facility with which slaty rocks may be split into thin plates. The word is synonymous with slate.

Scoriæ: (Lat.) In Geology this term means volcanic cinders.

Secondary Strata: The great middle division of stratified rocks. See p. 94.

Sedimentary Rocks: Rocks deposited from water. See p. 25, &c.

Septa: Partition, as in the shells of the nautili and ammonite.

Septaria: Flattened oval balls, or nodules, of stone. Ironstone is generally found in this state, and when split, are seen to be crossed in all directions with calcareous spar veins.

Serpentine: A beautiful green and whitish metamorphic rock, sometimes striped, found in Wales, and elsewhere; called so from its likeness in colour to the serpent. It takes a beautiful polish. Some varieties, as at the Lizard Point, have a dark ground, with brilliant red spots.

Serrated: From serro, to saw, Lat. Toothed, like a saw; jagged, or notched.

Shale: From the German schalen, to peel, or split. An indurated clay, sometimes siliceous, or sandy; so called from its readiness to split in parallel layers.

Shingle: The loose and water-worn pebbles and gravel on the sea-shore.

Sigillaria: An ancient gigantic reed, or reeds, found in the coal strata.

Siliceous: Any body impregnated with silex, (one of the pure earths,) or flint, is said to be siliceous, or silicified. See p. 9.

Silt: Sand, clay, or other earth, highly comminuted, and transported by running water, is silt. Thus the mouths of rivers are said to be silted up.

Silurian: The name given to the Wenlock, Dudley, and other rocks. See p. 33.

Sinter: A precipitate from mineral springs. Sometimes it is calcareous, and sometimes siliceous. That from the limestones is the former, and that from the hot springs of Iceland, &c. is of the latter.

Siphuncle: A small, membraneous tube, passing through the septa, or divisions in a chambered shell.

Situ: Placed; in situ; means, in its place.

Slickinsides: The smooth, striated surface of a fault; also an ore of lead.

Squaloid: Resembling a shark.

Stalactite, Stalagmite: See p. 65.

Steneosaurus: A genus of fossil saurians, (crocodilian,) with long and narrow beaks. Thus named by M. Geoffrey St. Hilaire.

Steppe: In Physical Geography, is a low plain.

Sternum: The breast-bone.

Stigmaria: The root of sigillaria, (ancient reed,) found in the under clay of the coal beds.

Stratified, Stratification: Rocks arranged in the form of strata. See p. 24.

Stratum, plural *Strata*: "When several rocks lie like the leaves of a book, one upon another," each one forms a stratum.

Strike: "The direction, or line of bearing of strata, which is always at right angles to their prevailing dip.

Sub-Appennines: Low hills which skirt the foot of the great chain of the Appennines in Italy.

Substratum: A stratum, or bed, lying under another.

Sulcated: From sulcus, a furrow, Lat. Furrowed, or grooved.

Superposition: A term used in Geology to describe the order of the arrangement of the strata. See p. 30.

Synclinical Axis: This term indicates a line, or lines, generally passing through the centre of those depressions, troughs, or narrow valleys, running nearly parallel to the ridges of hills which bound them. It always, however, has reference to the *depression* of the *line* of *strata*, whether higher or lower. The anticlinical axis is the *reverse* of this.

Synchronous: From συν, the same, and χρονος, time or age. Occurring at the same period of time.

Talus: A sloping heap, accumulated at the foot of a steep rock, or hill, owing to the decay or destruction of the rock, or washed down if the rock is soft and yielding.

Teleosaurus: A crocodilean reptile, allied to the gavial of the Ganges, about 18 feet in length, with a long and narrow beak, found in the alum shale near Whitby.—Buckland, Bridge. T. vol. i. p. 253.

Tentacles, *Tentacula*: Feelers; exploring organs. These are sometimes prehensory and locomotive, as in the nautili, &c.

Tertiary strata: See p. 116.

Testacea: Molluscous, or soft animals, having a shelly covering.

Testudinata: Tortoises.

Thermal: Warm, or hot: usually applied to hot springs.

Thinning out: Applied to strata that diminishes, feathers, or dies out.

Toad-stone: A name given to the Derbyshire basalt from its dirty colour, like a toad's back, or from the German todt-stein, dead stone, without ore.

Trachyte: From τραχυς, trachus, rough. A variety of lava; glassy felspar, which sometimes contain crystals of augite and hornblend.

Transition: A name formerly given to the Silurian and Old Red Sandstone rocks, from the idea that they were in a *transition state*; viz. merging into clay slate, mica schist, &c. The term is now abandoned as inapplicable.

Trap, and *Trappean Rocks*: Volcanic rocks, composed of felspar, augite, and hornblend. The word is derived from trappa, the Swedish for stair.

Travertin: A variety of stalagmite, largely deposited from hot springs in some of the rivers in Italy, (the Arno and Tiber, near Rome.) It was called Lapis Tibertinus by the Romans. It takes a splendid polish, and is worked into vases, &c. in Italy.

Trilobite: The Dudley fossil. See p. 35.

Tripoli: A siliceous rock, used for polishing metals and stones, formed of the siliceous casts of infusorial animals. See Note, p. 123.

Trionyx: Belonging to the order of chelonians. The soft-shelled tortoise.

Trough: (in Geology) "a basin-shaped, or oblong depression.

Tufa, Tufaceous: This is a term applied by the Italians to a volcanic rock; but in this country it is applied to all those calcareous deposits arising from the hot springs of Matlock, &c.

Turbinated: Shells which have a spiral, or screw-like structure, are so called.

Type: In Natural History, means a representative form, an emblem.

Unconformable: See p. 31.

Undercliff: The name applied to a cliff when the upper part has fallen down and forms a subordinate terrace along a line of coast between the sea and the original shore.

Univalve: A shell composed of but one piece. A *bivalve* has two.

Veins: Fissures, or cracks, in rocks filled in with lead, or other materials, accompanied often with fluor and calcareous spar, barytes, &c.

Vertebrata, or *Vertebrated Animals*: Those with a jointed back-bone. An important division in the animal kingdom.

Vesicular: Full of cells. From vesica, Lat. a bladder full of small cavities.

Vitrification: The conversion of a body into glass by heat.

Vitreous: Glassy.

Volcano: Vesuvius and Etna are volcanoes. The former always more or less in action. It is a hill of a conical shape, having at, or near the summit, a cup-shaped

depression, called the "crater." It is from this that gases, jets of steam, ashes, and volcanic bombs, or detached masses of melted lava, are ejected; the latter often thrown high up into the air, and on falling, assume rounded forms, like bomb-shells, and sometimes elongated into a pear-shape.

Volcanic foci: Are subterranean centres of igneous action.

Wacke: A German name for a variety of earthy basalt.

Water-shed: The line between two river basins.

Weathering: The wearing away of rocks. See p. 25.

Whinstone: A local term applied to trap or toadstone boulders.

Zamia: A variety of fossil plants allied to the cycads, wihch see.

Zoology: From ζωον, zoon, an animal; and λογος, logos, a discourse. The study of animals.

Zoophyte: From ζωον, an animal; and φυτον, phyton, plant. Corals, sponges, and other aquatic animals allied to them.

N.B.—Lest there should be any mistake respecting the "Dirt-bed," named at page 105, the Author begs to state, that the DIRT-BED of the Isle of Portland, which belongs to the lowest member of the Purbeck beds, contains *no Crinoideans*, but the upright stumps of trees; also the stems of silicified trees, lying prostrate, being the remains of an ancient submerged forest.

COLLECTIONS OF

ROCKS, MINERALS, AND FOSSILS,

Arranged and described to illustrate the Geology, are made up by Mr. Adam, on the following terms :—

		£.	s.	d.
Fifty specimens, arranged and described		0	10	0
Seventy ditto	ditto in a box	1	1	0
Ninety to one hundred ditto	in a box	1	10	0

And from this last sum to a *higher*, according to the *number* and *size* of the specimens.

Mr. Adam would be happy to arrange with Mechanics', and other Institutions and Schools, for Lectures, or a series of Lessons on Geology or Mineralogy, on the most *moderate* terms.

Also, for Geological excursions, or out-door readings on the stony leaf, by which the science of Geology may be *practically* and *speedily* learned. Address,

Mr. Adam,
Geologist,
Matlock,
Derbyshire.

Books published by the Author.

Price Six Shillings.

Dedicated, by permission, to His Grace the Duke of Devonshire.

THE GEM OF THE PEAK;

OR, A DESCRIPTION OF

MATLOCK, CHATSWORTH, HADDON, BUXTON, CASTLETON, DOVEDALE, HARDWICK, SOUTH WINGFIELD, NEWSTEAD, ALTON TOWERS, &c.

HISTORICAL, GEOLOGICAL, AND BOTANICAL

WITH MAPS, PLATES, AND NUMEROUS ENGRAVINGS,

SIXTH EDITION.

Also, price One Shilling,

MATLOCK AND ITS VICINITY,

HARDWICK, SOUTH WINGFIELD, DOVEDALE, ILAM HALL, ALTON TOWERS, DERBY, &c.

ABRIDGED FROM ADAM'S "GEM OF THE PEAK."

WITH INTAGLIO MAP.

Tenth Thousand.

Also, price One Shilling,

BUXTON AND ITS WATERS,

CHATSWORTH, HADDON HALL, BAKEWELL, CASTLETON, &c.

ABRIDGED FROM ADAM'S "GEM OF THE PEAK."

WITH INTAGLIO MAP.

Sixteenth Thousand.

Also, price One Shilling,

THE GEOLOGY, MINERALOGY, AND BOTANY OF DERBYSHIRE.

WITH SECTIONS OF THE STRATA.